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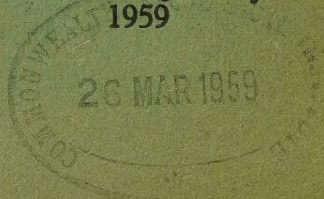
COFFEE RESEARCH STATION, RUIRU

AND

COFFEE RESEARCH SERVICES
KENYA

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INTRODUCTION

The unusually heavy rainfall in 1957 continued on into the period of 1958 under review (January-March, 1958). In the absence of the usual dry weather in the first quarter of 1957 leaf rust infections increased in severity and normal control measures were at times ineffective. Defoliation due to leaf rust and insect damage was to some extent the cause of the lower coffee quality produced in the early crop. Well-distributed rainfall affected the maturation of the 1957/58 crop which was earlier than usual and, in addition, brought out a heavy flowering in the Short Rains, i.e., October-November, 1957. The usual Long Rains flowering commenced in February, 1958, with the early onset of a prolonged Long Rains period.

Rainfall at the Department's Coffee Stations during 1957 (inches)

1957	A	B	C	D	E
January . . .	8.35	9.04	5.17	2.25	4.74
February . . .	0.64	1.48	0.82	0.36	1.42
March . . .	1.91	1.23	2.34	2.89	3.55
April . . .	12.65	8.82	9.59	6.51	12.03
May . . .	15.99	13.24	11.42	9.23	15.54
June . . .	2.64	1.84	0.60	4.46	4.16
July . . .	0.48	0.34	0.05	5.01	1.04
August . . .	0.35	0.34	0.11	6.25	0.75
September . . .	1.27	1.20	0.60	0.60	1.36
October . . .	4.09	2.35	2.75	0.73	3.61
November . . .	6.42	6.20	7.96	1.94	6.54
December . . .	3.87	2.46	3.70	0.92	3.77
Total . . .	58.66	48.54	45.11	41.15	58.51
Total days . . .	128	111	96	136	182
10-year means 1948-1957 . . .	36.75	37.12	35.25	44.72	49.94

- A = Coffee Research Station, Ruiru.
- B = Scott Agricultural Laboratories.
- C = Maji Kiboko Estate for Makuyu Sub-station.
- D = Kitale Experimental Station.
- E = Mabroukie factory for Upper Kiambu Sub-station.

There were a number of changes in the staff during the year which included the appointment of Mrs. J. M. Pollitt in the office and Mr. P. Gacoka on probation in the Chemistry Laboratory. Mr. P. Thoms was appointed a Senior Assistant Agricultural Officer. Mr. J. S. Grant, Assistant Agricultural Officer, who was seconded to assist with the Coffee Processing Research, retired from the service in January, 1958. Mr. S. D. Goodwin was transferred from the Kitale Experimental Station to take over the new Upper Kiambu Sub-station in November, 1958, and Mr. H. H. J. de Vink took over from him at Kitale. Dr. F. J. Nutman and his team continued to pursue their researches into Coffee Berry Disease and their report appears in this volume. A considerable amount of progress has been made in this field of coffee investigation.

The special coffee drying project being carried out by Mr. J. F. McCloy, of the East African Industrial Research Organization, advanced in several aspects. Knowledge of light wavelength and its influence on the appearance of both parchment and raw green coffee and the effect of heating the bean on the degree of sourness in the liquor has been acquired. This type of information is essential if a mechanical drier is to be designed which will maintain the inherent quality of the bean and the beverage derived therefrom. Again, full reports of these studies have been issued by the East African Industrial Research Organization.

The results from the field experiments were interesting. Both the Cultivation and the Rotavator trials have illustrated the great value of clean weeding the coffee throughout the rains in terms of crop yield increases. Yield responses to cattle manure applications were recorded in Manurial Trials I and II in 1957 and nitrogen fertilizers produced a yield increase in all trials. However, the summarized interaction results, over eight years, of nitrogen $\times$ cattle manure in Manurial Trial II show very clearly that whereas heavy cattle manure applications alone or nitrogen fertilizer applied alone have resulted in yield increases, combining the two treatments has more than halved the nitrogen fertilizer responses.

For the eleventh year in succession, use of a phosphate fertilizer has not increased coffee yields. Double superphosphate was replaced by basic slag in 1957 because it was felt that the other constituents of this fertilizer might also be beneficial.

Anti-leaf-fall treatments in the different trials have again demonstrated the value to be obtained from the May spraying. Yield results from the irrigation trial have been disappointing and this is attributed to the good rainfall. The irrigation advisory service is functioning in a small way at present but it is felt that in years of less favourable rainfall a greater use will be made of this service.

Further study of mulch $\times$ nitrogen fertilizer interactions by the Agricultural Chemist have indicated that the timing of the main Long Rains nitrogen fertilizer application may influence the shape of the growth curve of the coffee. Results from this experiment, and others conducted in parallel and in previous years, suggest that fertilizer nitrogen applications, at the higher rates especially, should be split in the Long Rains for optimum effect.

Further laboratory soil incubation studies have exposed the fallacy of pre-drying field samples for incubation studies if it is the object to simulate field conditions and/or determine the natural nitrate nitrogen production potential. The one possible exception to this finding has been when soil samples are collected in a dry or drought time before the onset of the rains. Some results on this problem were published in the 1956/57 Annual Report and similar conclusions have since been reached in Southern Rhodesia (*J. Soil Sci.*, 1957, 8, 301) in respect of annual crops.

The investigation of magnesium nutrition of coffee has been continued following the identification of a deficiency syndrome in coffee during 1956. Deficiency of magnesium appears to be generally widespread throughout the coffee-growing areas, particularly in the presence of heavy crops, and is undoubtedly related to the particular use of Napier grass as a mulch. Two full-scale field trials have been laid down with magnesium fertilizers; some plots of an existing mulch trial have been split for the application of magnesium fertilizer and some work has also been commenced with the foliar application of magnesium as a field spray.

Further yield data have been obtained from the Napier grass mulch and pineapple crops on the camber bed vlel trial and a second vlel area has been cultivated to the same system; varying sizes of bed width are being compared on the second area.

The attention of the Pathologist has been engaged almost wholly with studies of the Leaf Rust (*Hemileia vastatrix*) problem. The investigation of the breakdown of the K.7 variety has been undertaken; the different physiologic races of the rust known to occur in Kenya have been studied further in respect of local selections and imported material. It is confirmed in one experiment that spores are more likely to land on upper leaf surfaces in the field and that these reach the under surface of the leaf by rain washing and splashing. This suggests that upper leaf surface deposits of copper fungicides may operate in suppressing spore germination since some copper will also move with the spore in the water droplets.

The Entomologist carried out further studies on the life history of leaf miners with a view to determining the intervals at which it would be necessary to spray. A very satisfactory control of *Antestia* is now possible with malathion.

With the advance of the lacebug infestation in the East Rift coffee areas a trial of insecticides against this insect showed that a parathion emulsion concentrate, closely followed by malathion, would give the best control. Since the latter material is much safer to use this has become the recommended control. Two applications are necessary in order to kill those bugs which hatch from eggs not eliminated by the first spray.

A second dieldrin $\pm$ resin spray banding experiment for the control of white borer is also reported; the campaign for the elimination of this pest in the lower coffee altitudes East of the Rift is proceeding satisfactorily.

Capital improvements planned for the Rukera Demonstration Farm are now virtually completed. A small part of the fruit sub-station's bench terraces was taken over and a small coffee nursery has been established thereon to provide plants for the replanting scheme which is to start in 1959/60. A total of about 15,700 lb. of Washington navel oranges were picked from the two acres of commercial planting on the fruit sub-station. As more land in this area reverts to the Demonstration Farm the opportunity will be taken to extend the citrus acreage to an economic level as a secondary enterprise.

A total of 30.46 tons of clean coffee and 16.89 tons of mbuni were harvested from 78 acres of coffee in production on Rukera Demonstration Farm; 49% of the former was classified in the first three quality classes. A total of 2,590 lb. of parchment were prepared as coffee seed from two clonal blocks of SL.28 and SL.34; a clean coffee allowance for this has been added to the total weight of the crop quoted above.

Regular liaison was maintained by the Agricultural Officer (African Areas) between this Research Station and all districts of Central and Nyanza Provinces and the Machakos District. The Teita, Kitui and West Suk Districts were also visited during the year.

The coverage of variety trials is developing and prospective coffee zones were extended by additional trials planted in most districts. The variety trial programme is now reaching the point where valuable information is beginning to accrue from which the pattern of relative performance may be expected to become increasingly evident.

Three courses, each of a fortnight's duration, were held for departmental staff concerned with the development of coffee in African areas; the third conference of all departmental officers working in coffee was held at Jacaranda in February, 1958. Group visits to the Research Station by African coffee planters have now become a regular feature.

The two coffee sub-stations, one at Kisii and one near Meru, continued in the development phase and it is estimated that a period of three to four years will be necessary to initiate the full programme of field investigations.

ADVISORY AND EXTENSION SERVICES

It may be claimed with justification that the advisory services have been intensified during the period under review. Apart from an increasing call upon Specialist Officers for advice and *ad hoc* investigations of uncommon problems, there has been a considerable rise in the level of routine advisory work.

The Advisory Officer, East Rift, visited more estates in the Nairobi area than in any previous year. Farther afield he made advisory tours to the Rift Valley Districts in May, July, October, 1957, and January, 1958, and to Nyeri District in August, 1957, and March, 1958. In all he has visited a total of 203 estates during the year.

Advisory tours were made by the Senior Research Officer to Machakos, the Rift Valley (twice) and in Nyanza with the Agricultural Chemist (in March, 1958) who also toured the coffee estates in the Nyeri District in August, 1957.

Activities in the field of extension were diverse, including an exhibit in the Coffee Board Pavilion at the Royal Agricultural Society of Kenya's Show in October, 1957, participation in the R.A.S.K. Farmers' Day in Solai, the annual coffee lectures at Egerton Agricultural College, field days at the Coffee Research Station (Jacaranda and Rukera Estate), Ruiru, and at Makuyu and a number of discourses to district group meetings. This latter activity should be encouraged to a greater extent in future years as it is a stimulating way for discussing current problems in coffee and an excellent method of passing out advisory and extension information to the industry.

The notes provided in the Monthly Bulletin of the Coffee Board of Kenya under the heading "Better Coffee Farming" were continued as a means of disseminating information on topical problems. Large numbers of letters requesting information, advice and publications have also been dealt with by correspondence, the volume of which grows in frightening proportion as one year succeeds another.

PUBLICATIONS

The following articles were published in the Monthly Bulletin of the Coffee Board of Kenya :—

VOL. XXII

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| May | “Annual Report for Coffee Team Services,” by P. A. Jones. |
| June | “The Control of Antestia (<i>Antestiopsis</i> spp.) with Malathion,” by D. J. McCrae. |
| July | “Letter to the Editor re Nitrogen and Soil pH,” by J. B. D. Robinson. |
| November | “Report on a Study Tour of some Coffee Research Centres in Central and South America”—(Part I), by J. B. D. Robinson. |
| December | “Advice in the Control of Coffee Leafminers,” by D. J. McCrae.
“Report on a Study Tour of some Coffee Research Centres in Central and South America”—(Part II), by J. B. D. Robinson. |

VOL. XXIII

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| January | “Report on a Study Tour of some Coffee Research Centres in Central and South America”—(Part III), by J. B. D. Robinson. |
| February | “Report on a Study Tour of some Coffee Research Centres in Central and South America”—Conclusions and Appendix I, Leaf Analysis at the Coffee Research Station, Ruiru, by J. B. D. Robinson. |
| March | “Insect Pests and Insecticides. Table of important Coffee Insect Pests and Insecticides which can be used against them,” by D. J. McCrae. |

Articles published in other journals during the year were as follows :—

- | | |
|--------------------|--|
| Robinson, J. B. D. | Preliminary results of studies with urea fertilizer applied to Arabica Coffee. <i>E. Afr. Specialist Soil Fert. Comm.</i> , February, 1958. |
| Robinson, J. B. D. | The Critical relationship between soil moisture content in the region of wilting point and the mineralization of natural soil nitrogen. <i>J. Agric. Sci.</i> , 1957, 49 , 100. |
| Robinson, J. B. D. | Some chemical characteristics of “Termite Soils” in Kenya coffee fields. <i>J. Soil Sci.</i> , 1958, 9 , 58. |

FIELD INVESTIGATIONS

CULTIVATION TRIAL

Following the 1956 crop one of the three multiple-stem heads of each tree was removed and the remaining heads were cut up to leave three feet of bearing wood per head. New sucker growth which had developed during the latter part of 1956 was thinned out on December 31, 1956, to leave four good suckers on each tree. On May 17, 1957, a final selection of suckers for the new cycle was made so as to leave three young suckers per tree.

Growth measurements

Between July 29 and 31, 1957, the diameter of each old head was measured with calipers at a point 15 cms. above the points of origin.

TABLE I

The diameter of multiple-stem heads about 5½ years old measured in cms. at 15 cms. above the point of origin of each head

(Means of 720 heads)

Weeding treatment	Mean stem diameter	% of W_0
W_0 . Clean weeded	4.345	100.0
W_1 . Weeds slashed	4.017	92.5
W_2 . Tall weeds	3.960	91.1
C. of V. %	2.56	
<i>Least Significant Difference</i>		
$p = 0.05$	0.104	
$p = 0.01$	0.143	
$p = 0.001$	0.197	

Only the weeding treatments had produced a measurable effect on the stem diameter. The results are summarized in Table I which shows that on the clean weeded plots the stems were 7.5% thicker than on the plots on which weeds had been slashed (W_1) and 8.9% thicker than those on plots on which weeds had been uncontrolled during the rains (W_2). Both these differences are statistically significant at $p = 0.001$. There was no significant difference between W_1 and W_2 .

In order to examine the effects of the various treatments on the vegetative growth of the coffee trees measurements were made on the young suckers which were allowed to develop to replace the old multiple-stem heads.

On March 21, 1957, four suckers were selected at random on each of the 54 sub-plots of the experiment. Each sucker was measured from its point of origin to the base of the terminal bud. An analysis of these figures showed that on the clean weeded plots (W_0) suckers were significantly ($p = 0.05$) larger than on the slashed plots (W_1) and highly significantly ($p = 0.01$) larger than those on the "tall weed" plots (W_2). There was, however, an interaction between the weeding treatments and the implements so that clean weeding with a forked hand hoe (W_0T_0) and slashing weeds during the rains and disking at the end of the wet seasons (W_1T_1) had produced suckers highly significantly ($p = 0.01$) larger than those on plots on which the weeds had been slashed during the rains and the ground forked at the end of the wet season. In Table II it may be seen that several other comparisons attain statistical significance but their importance remains obscure.

TABLE II
Initial Length of Suckers on 21.3.57 (measurements in cms.)
T × *W* Interaction Table

	<i>W</i> ₀ Clean weeding	<i>W</i> ₁ Weeds slashed	<i>W</i> ₂ Tall weeds	Means
<i>T</i> ₀ . Forked hand hoe	32.51	22.35	22.28	25.71
<i>T</i> ₁ . Disc-harrow	30.13	32.42	25.27	29.27
<i>T</i> ₂ . Mouldboard plough	29.92	24.31	22.92	25.71
Means	30.85	26.36	23.49	
Least Significant Difference	Within the table		Between original means	
<i>p</i> = 0.05	7.04		4.08	
<i>p</i> = 0.01	9.70		5.63	
<i>p</i> = 0.001	13.33		7.73	

TABLE III
Sucker Growth Between 15.11.57 and 25.2.58 (Measurements in cms.)
C × *W* Interaction Table

	<i>W</i> ₀ Clean weeding	<i>W</i> ₁ Weeds slashed	<i>W</i> ₂ Tall weeds	Means
Athi Plains manure + <i>C</i>	28.22	29.86	31.24	29.78
No manure - <i>C</i>	35.74	29.91	27.12	30.93
Means	31.98	29.89	29.18	
Least Significant Difference	Within the table		Between + <i>C</i> and - <i>C</i>	
<i>p</i> = 0.05	5.87		3.38	
<i>p</i> = 0.01	7.98		4.59	

The same suckers were measured again after the Long Rains (July 5, 1957), early in the Short Rains (November 15, 1957) and after the Short Rains (February 25, 1958). In each case the increases in sucker length were analysed and a summary of this data is given in Table IV. During the period March 21-July 5, which included the main Long Rains growth period, there was no significant difference between the growth of the suckers on the plots under the various treatments of the experiment. During the dry season between July 5 and November 15 there was again no significant difference between treatments but the growth between November 15, 1957, and February 25, 1958, revealed an interesting interaction between the Athi Plains manure treatment and the weeding treatments. Where the manure had been applied at the rate of one 4-gallon tin a year (last application March 9, 1957) there was no significant difference between the growth of the suckers on the plots receiving the three methods of weeding treatment, but in the absence of manure the sucker growth on the clean weeded plots was highly significantly (*p* = 0.01) greater than on the tall weed plots. The growth of suckers on the *W*₁ plots was intermediate between *W*₀ and *W*₂.

A summary of the sucker growth measurements is given in Table IV. Although no startling differences are apparent it seems probable that the sucker growth on the clean weeded plots is superior to that on the other plots. This difference only reached statistical significance in the initial measurements which were in effect an approximate record of the growth during the period November, 1956-March, 1957 and thus covering the same season of year as given by the difference between the measurements of November 15, 1957, and February 25, 1958, when there were also statistically significant differences between treatments. The indications are then that the various treatments of this trial exert their greatest influence on vegetative growth during the period between November and March or, in other words, during the recovery period following the removal of the coffee crop.

TABLE IV

A Summary of Sucker Growth Measurements (cms.)

	<i>Initial measurement sucker length 21.3.57</i>	<i>21.3.57- 5.7.57 sucker length increase</i>	<i>5.7.57- 15.11.57 sucker length increase</i>	<i>15.11.57- 25.2.58 sucker length increase</i>	<i>Total sucker length on 25.2.58</i>
T ₀ . Forked hand hoe	25.71	34.50	35.03	32.64	127.88
T ₁ . Disc-harrow	29.27	33.63	32.17	28.85	123.92
T ₂ . Mouldboard plough	25.71	33.83	30.98	29.56	120.08
W ₀ . Clean weeding	30.85	33.92	33.70	31.98	130.45
W ₁ . Weeds slashed	26.36	33.44	30.77	29.89	120.46
W ₂ . Tall weeds	23.49	34.60	33.70	29.18	120.97
<i>Least Significant Difference</i>					
p = 0.05	4.08	5.95	6.29	4.25	
p = 0.01	5.63	—	—	5.85	
p = 0.001	7.73	—	—	8.04	
C. of V. %	7.56	8.71	9.57	6.97	

Yield records

Although only 6 ft. of bearing wood had been left on each tree after the 1956 crop yet the mean yield for this trial in 1957 was 11.67 cwt. of clean coffee per acre.

In 1957 there was no significant difference between the implements when used for any of the weeding treatments (Table V) but although there was no overall significant difference between implements during the period 1952-1957, yet where the weeds were slashed the plots cultivated with a mouldboard plough yielded significantly more than the forked plots (Table VI).

TABLE V

1957

(Yield expressed in cwt. clean coffee per acre)

<i>Implement</i>	<i>Weeding Regime</i>			<i>Means</i>
	<i>W₀. Clean weeded</i>	<i>W₁. Weeds slashed</i>	<i>W₂. Tall weeds</i>	
T ₀ . Forked hand hoe	12.19	12.21	10.20	11.53
T ₁ . Disc-harrow	14.19	10.58	9.41	11.39
T ₂ . Mouldboard plough	13.97	10.82	11.44	12.08
Means	13.45	11.20	10.35	
C. of V. %	11.94			
<i>Least Significant Difference</i>	<i>Within the table</i>		<i>Between marginal means</i>	
p = 0.05	2.42		1.38	
p = 0.01	3.32		1.90	
p = 0.001	4.57		2.61	

TABLE VI
1952-1957
Summary of Six Years' Results
(Mean annual yields in cwt. clean coffee per acre)

<i>Implements</i>	<i>Weeding Regime</i>			<i>Means</i>
	<i>W₀ Clean weeded</i>	<i>W₁ Weeds slashed</i>	<i>W₂ Tall weeds</i>	
T ₀ . Forked hand hoe	11.15	8.26	6.75	8.72
T ₁ . Disc-harrow	10.90	8.86	6.95	8.90
T ₂ . Mouldboard plough	10.35	9.31	6.74	8.80
Means	10.80	8.81	6.81	
C. of V. %	6.04			
<i>Least Significant Difference</i>	<i>Within the table</i>		<i>Between marginal means</i>	
p = 0.05	0.92		0.53	
p = 0.01	1.27		0.73	
p = 0.001	1.74		1.00	

In 1957 the clean weeded (W₀) plots once again outyielded the plots on which the weeds had been slashed (W₁) or had been left during the rains (W₂), but a close inspection of Table V will reveal curious irregularities in the response. Since similar irregularities are not apparent in the six-year yields shown in Table VI it is unlikely that they are of importance, for it may be seen that whichever implement has been used the clean weeded plots have yielded very highly significantly ($p = 0.001$) more than the "tall weed" plots while the yields from the slashed plots take an intermediate position. In the mean yields for weeding treatments the differences are all significant at the $p = 0.001$ level.

The Athi Plains manure treatment led to valuable yield increases in 1957 (Table VII). The forked plots which received manure yielded more ($p = 0.05$) than those without manure, and a similar response was evident on the plots on which the weeds were slashed during the rains.

TABLE VII
Athi Plains Manure, 1957
(Yield in cwt. clean coffee per acre)

	<i>1 4-gall. tin per tree/year +C</i>	<i>Nil -C</i>	<i>Difference attributable to manure</i>
T ₀ . Forked hand hoe	12.84	10.21	+2.63
T ₁ . Disc-harrow	12.26	10.51	+1.75
T ₂ . Mouldboard plough	12.61	11.53	+1.08
W ₀ . Clean weeding	13.96	12.92	+1.04
W ₁ . Weeds slashed	12.60	9.79	+2.81
W ₂ . Tall weeds	11.15	9.54	+1.61
Mean	12.57	10.75	+1.82
C. of V. %	21.05		
<i>Least Significant Difference</i>	<i>Within the table</i>		<i>Between means</i>
p = 0.05	2.32		1.34
p = 0.01	3.15		1.82
p = 0.001	4.24		2.45

TABLE VIII
Athi Plains Manure, 1952-1957
(Mean annual yields in cwt. clean coffee per acre)

	1 4-gall. tin per tree/year +C	Nil -C	Difference attributable to manure
T ₀ . Forked hand hoe	9.19	8.24	+0.95
T ₁ . Disc-harrow	9.43	8.35	+1.08
T ₂ . Mouldboard plough	8.98	8.60	+0.38
W ₀ . Clean weeding	11.06	10.52	+0.54
W ₁ . Weeds slashed	9.22	8.38	+0.84
W ₂ . Tall weeds	7.32	6.29	+1.03
Means	9.20	8.40	+0.80
C. of V. %	8.72		
<i>Least Significant Difference</i>	<i>Within the table</i>	<i>Between means</i>	
p = 0.05	0.75	0.43	
p = 0.01	1.02	0.59	
p = 0.001	1.38	0.79	

Table VIII shows that over the six-year period 1952-1957 the manure has increased the annual yield of clean coffee by 0.80 cwt. per acre ($p = 0.001$). The response has been most marked on the disced plots and on those unweeded during the rains.

Summary

The value of good weed control during the rains has been shown consistently throughout the 11 years this trial has run. Over the six years 1952-1957 the clean weeded plots have yielded 2 cwt. of clean coffee per acre more than the plots on which the weeds were slashed during the rains and 4 cwt. per acre a year more than the plots on which there was no weed control during the rains. In dry years this benefit has been attributed to the greater amount of moisture available to the trees on the clean weeded plots. There was, however, a marked response to clean weeding in 1957 which was the wettest year on record and during which there was adequate soil moisture throughout the crop season. It seems probable that this was a result of the cumulative benefit of clean weeding for many years which has allowed the development of robust coffee stems (Table I) and vigorous suckers (Tables II and IV). It is clear also that at the beginning of the rains the quick-growing weeds compete seriously with the coffee trees for plant nutrients in general and nitrogen and possibly phosphorus in particular.

The differences between implements recorded during the period 1946-1951 have become progressively less distinct so that no significant differences may be detected in the mean yields for the period 1952-1957.

The yield response to Athi Plains cattle manure has been irregular throughout the course of this trial but over the period 1952-1957 there has been a positive mean annual response of 0.80 cwt. of clean coffee per acre.

ROTAVATOR TRIAL

There continues to be no significant difference in the yields of coffee from plots cultivated with a forked hand hoe or a modified rotary hoe ("The Coffee Rotavator"). The advantages of clean weeding and mulching continue to be demonstrated in this trial. From the 3-year mean annual yields in Table IX it may be seen that clean weeding has increased the annual crop by 1.45 cwt. clean coffee per acre and mulching alternate inter-rows in alternate years has raised the crop by 1.13 cwt.

TABLE IX
Yield Summary 1954-1957
(Mean annual yields in cwt. clean coffee per acre)

Treatment	1957	1954-1957
<i>Implement</i>		
R. Rotavator	11.56	7.37
F. Forked hand hoe	11.14	7.14
Level of Significance	NS	NS
<i>Weeding during Rains</i>		
W ₀ . Clean weeding	13.27	7.98
W ₂ . No weeding	9.43	6.53
Level of Significance	xxx	xx
<i>Mulching</i>		
+M. Alternate inter-rows	11.98	7.82
—M. Nil	10.72	6.69
Level of Significance	x	xx
C. of V. %	11.69	6.70
<i>Least Significant Difference</i>		
x p = 0.05	1.45	0.69
xx p = 0.01	2.14	1.02
xxx p = 0.001	3.31	1.58

TABLE X
Important Interactions 1954-1957
(Mean annual yields in cwt. clean coffee per acre)

<i>Implement</i>	<i>Implement × Mulch</i>			<i>Implement × Weeding</i>		
	<i>Mulch treatment</i>			<i>In Rains weeding treatment</i>		
	<i>Nil</i>	<i>Alternate inter-rows</i>	<i>Difference</i>	<i>Clean weeding</i>	<i>No weeding</i>	<i>Differences</i>
Rotavator Level of Significance	6.54	8.21	+1.67 xx	7.98	6.77	+1.21 x
Forked hand hoe Level of Significance	6.85	7.43	+0.58 NS	7.98	6.30	+1.68 xx
Differences Level of Significance	+0.31 NS	—0.78 NS		0.00 NS	—0.47 NS	
<i>Least Significant Difference</i>						
x p = 0.05	0.97					
xx p = 0.01	1.44					
xxx p = 0.001	2.23					

Some curious interactions are shown in Table X. The full advantage of mulch is only apparent where the Rotavator has been used for there is no significant difference between the yields from the mulched and the unmulched plots cultivated with a forked hand hoe. The second part of Table X showed that the hand-forked plots were more sensitive to weed competition than were the Rotavator plots.

The conclusion from this trial so far is that a modified rotavator may be used to cultivate coffee plantations with little fear of direct or indirect adverse effects on the crop.

IRRIGATION TRIAL

When this trial was commenced in May, 1956, it was decided that the irrigation treatments incorporated in the design of the experiment would only be applied if there was a soil moisture deficit. The quantities of water applied by the sprinkler system are summarized in Table XI.

TABLE XI
*Quantities of water (inches) applied during 1956 to the "Overhead" Irrigation Treatments.
Half these quantities were applied to the "Ground" Irrigation Treatments*

	One irrigation per year			Two irrigations per year			Three irrigations per year
<i>Treatments</i>	<i>b</i>	<i>c</i>	<i>a</i>	<i>bc</i>	<i>ab</i>	<i>ac</i>	<i>abc</i>
(b) After Long Rains 6.6.56	4			4	4		4
(c) August "crop- saver" 16.8.56		10		6		10	6
(a) After Short Rains 17.12.56			8½		5	3	3

In 1957 the rainfall was so great and so well distributed that at none of the three irrigation times was there a sufficient soil moisture deficit to warrant irrigation.

TABLE XII
*Yield Summary 1956-1957
(Mean annual yields in cwt. clean coffee per acre)*

<i>Irrigation season</i>	<i>Crop season</i>	
	<i>1956</i>	<i>1957</i>
+a. In December	—	10.99
—a. Not in December	—	10.72
+b. In May/June	11.73	11.42
—b. Not in May/June	11.87	10.29
+c. In August	12.30	11.11
—c. Not in August	11.30	10.60
C. of V. %	12.08	10.13
Least Significant Difference $p = 0.05$	1.42	0.96
<i>Method of Application</i>		
O. Sprinkler	12.55	10.28
G. Ground	11.05	11.44
C. of V. %	24.91	25.75
Least Significant Difference $p = 0.05$	1.72	1.71

The yields for the first two crops from this trial are given in Table XII but, as might be expected, there is no significant difference between any of the treatments for the trial commenced when the 1956 crop was half-formed and no irrigation was applied in 1957.

MULCH TRIAL

Yield

As in 1955 so in 1957 the unmulched plots produced substantially more clean coffee than did plots under any of the three mulch treatments. The main reason for this appears to be that while the unmulched plots have carried very regular crops throughout the multiple-stem pruning cycle 1952-1957 the yields from the mulched plots have been fluctuating from 7 cwt. to 21 cwt. of clean coffee per acre (Table XIII). This suggests that the level of pruning adopted has been suited to the unmulched plots but has permitted the mulch plots to overbear in 1954 and 1956.

TABLE XIII
The Effect of Biennial Bearing on the Yield Response to Mulching
(Mean annual yields in cwt. clean coffee per acre)

Year	Without mulch Means of 16 plots	With mulch Means of 48 plots	Effect of mulch
1950	0.77	1.11	+0.34
1951	6.69	10.75	+4.06
1952	3.16	2.55	-0.61
1953	6.34	7.21	+0.87
1954	11.30	16.88	+5.58
1955	11.74	7.00	-4.74
1956	12.17	21.88	+9.71
1957	11.69	6.91	-4.78
Mean annual yield	7.98	9.28	+1.30

TABLE XIV
The Main Effects of the Mulch Treatments 1950-1957
(Mean annual yields in cwt. clean coffee per acre)

Mulch treatments	1957	1950-1957
(1). No mulch	11.69	7.98
(a). All inter-rows pre-Long Rains—March	5.45	9.22
(b). Alternate inter-rows pre-Long Rains—March	7.39	8.91
(ab). All inter-rows post Long Rains—July	5.89	9.10
C. of V. %	33.59	8.78
Least Significant Difference		
p = 0.05	1.85	0.64
p = 0.01	2.49	0.86
p = 0.001	3.31	1.14

There is no significant difference between the mean annual yields (1950-1957) of the three mulch treatments and all are significantly greater than that from the unmulched plots. In the yields for 1957 alone it may be seen that the alternate row mulch treatment is superior to the all-row treatments. It seems probable that this is not a real effect but rather a reaction from the previous year when the position was reversed. The mean yields for the eight years that this trial has been in full progress show that the all-row mulches are if anything superior to the alternate row treatment.

In this trial the response to the nitrogenous fertilizer treatments has been poor. As Table XV shows, in 1957 there was no significant difference between treatments though over the period 1954-1957 an annual application of 46 lb. per acre of nitrogen in the ammonium form has increased the mean annual coffee yield by 0.95 cwt./acre ($p = 0.05$). In the mean annual yields for 1951-1957 shown in Table XV it may be seen that when applied alone, both forms of nitrogen have increased the yield ($p = 0.05$), but when applied together they have not affected the crop significantly.

TABLE XV
The Main Effects of the Nitrogenous Fertilizer Treatments
(Mean annual yields in cwt. clean coffee per acre)

Rate of Nitrogen per acre	23 lb. N/year	46 lb. N/year		1951-1957
Period	1951-1953	1957	1954-1957	
(1). No nitrogen	6.23	7.57	11.92	9.47
(d). Ammonium form	6.55	8.57	12.87	10.12
(e). Nitrate form	6.90	7.03	12.71	10.21
(de). $\frac{1}{2}$ Ammonium form $\frac{1}{2}$ Nitrate form	6.32	7.26	12.50	9.84
C. of V. %	11.92	33.59	8.86	8.88
Least Significant Difference				
p = 0.05	0.56	1.85	0.80	0.64
p = 0.01	0.75	2.49	1.08	0.86

TABLE XVI
Mulch $\times$ Nitrogenous Fertilizer Interaction Table
(Mean annual yields in cwt. clean coffee per acre)

1957	Nitrogenous Fertilizer 46 lb. N/acre				Mean yields for mulch treatments
	Nil	Ammonium form	Nitrate form	$\frac{1}{2}$ Ammonium $\frac{1}{2}$ Nitrate	
(1). No mulch	10.09	12.14	13.72	10.82	11.69
(a). All inter-rows pre- Rains—March	6.59	5.75	4.82	4.66	5.45
(b). Alternate inter-rows pre- Rains—March	6.88	10.15	5.78	6.76	7.39
(ab). All inter-rows post Rains—July	6.71	6.23	3.81	6.83	5.89
Mean yields for Fertilizer treatments	7.57	8.57	7.03	7.26	7.60
Least Significant Difference	Within the table		Between marginal means		
p = 0.05	3.70		1.85		
p = 0.01	4.98		2.49		
p = 0.001	6.62		3.31		
1951-1957					
(1). No mulch	8.14	9.42	9.80	8.67	9.01
(a). All inter-rows pre- Rains—March	10.27	10.06	10.50	10.42	10.31
(b). Alternate inter-rows pre- Rains—March	9.41	10.59	10.57	9.52	10.02
(ab). All inter-rows post Rains—July	10.07	10.40	9.98	10.75	10.30
Mean yields for Fertilizer treatments	9.47	10.12	10.21	9.84	
Least Significant Difference	Within the table		Between marginal means		
p = 0.05	1.28		0.64		
p = 0.01	1.72		0.86		
p = 0.001	2.29		1.14		

The slight yield response to applications of nitrogen to a mulch trial suggests a negative mulch $\times$ nitrogen interaction and there is some evidence of this in Table XVI. Within the table of yields for 1957 there is no significant difference between the response to nitrogen in the presence or absence of mulch; in no case have the fertilizer treatments affected the yields significantly. The mean annual yields for 1951-1957 reveal that in the absence of mulch both the ammonium and the nitrate fertilizer treatments have increased the yield of coffee slightly, but significantly ($p = 0.05$). Where mulch has been applied the yields appear unaffected by the fertilizer treatments.

TABLE XVII

<i>Treatment</i>	<i>1950-1953 1 $\times$ 4-gall. tin/tree</i>	<i>1957 2 $\times$ 4-gall. tin/tree</i>	<i>1950-1957</i>
+ C. Composted cattle manure	5.16	7.61	8.95
- C. Nil	5.07	7.60	8.65
<i>Least Significant Difference</i>			
$p = 0.05$	0.30	1.31	0.40
$p = 0.01$	0.41	1.76	0.53

Neither in the 1957 yields nor in the mean annual yields for 1950-1957 has there been any response to the applications of composted cattle manure.

Growth

After the 1956 crop had been picked one of the three heads on each multiple-stem tree was removed and the remaining two cut up to leave 3 ft. of bearing wood per head. During the latter part of 1956 young suckers were allowed to develop and these were reduced to four per tree at the time of pruning and subsequently reduced to three per tree half-way thorough 1957.

On March 26, 1957, four suckers were selected at random on each of the 64 plots of the trial. The length of each sucker was measured from its point of origin to the base of the terminal bud. These measurements were repeated after the Long Rains (July 8, 1957), the Short Rains (November 28, 1957) and finally on February 3, 1958. A summary of these measurements is given in Table XVIII.

TABLE XVIII
A Summary of Sucker Growth Measurements (cms.)
(Means of 64 plots)

<i>Mulch treatment</i>	<i>Initial length of suckers</i>	<i>Increase during 26.3.57- 8.7.57</i>	<i>Increase during 8.7.57- 28.11.57</i>	<i>Increase during 28.11.57- 3.2.58</i>	<i>Total</i>
(1). No mulch	36.29	39.42	39.50	19.43	134.64
(a). All inter-rows pre-Long Rains—March	34.65	46.68	52.84	22.87	157.04
(b). Alternate inter-rows pre-Long Rains March	34.15	45.43	48.19	21.80	149.57
(ab). All inter-rows post Long Rains—July	37.70	46.63	51.00	22.33	157.66
C. of V. %	14.85	12.96			
<i>Least Significant Difference</i>					
$p = 0.05$	3.84	4.17			
$p = 0.01$	5.18	5.63			
$p = 0.001$	6.89	7.49			

There is no significant difference between the lengths of the suckers in March, 1957, but both during the Long Rains and between the Long and the Short Rains 1957 the growth of the suckers was greater on the mulched than on the unmulched plots. During the 11 months covered by these recordings the suckers on the mulched plots grew about 20 cms. more than those on the control plots. This increase in growth will presumably result in an increase in the amount of bearing wood on the mulched plots, but it should be realized that during the course of these growth measurements the unmulched plots were bearing a crop of 11.69 cwt. while the mulched plots only carried an average of 6.91 cwt. of clean coffee per acre.

MANURIAL TRIAL I

In 1957, 100 lb. of urea per acre was applied to the N_1 plots which had received 1 cwt./acre of sulphate of ammonia for each of the previous ten years 1947-1956. The N_2 treatment was unaltered and still consists of an annual dressing of 2 cwt. an acre of sulphate of ammonia. Each of the treatments N_1 and N_2 now supplies 46 lb. of nitrogen per acre but it is provided in different nitrogenous fertilizers.

Results

A very heavy crop was carried on all plots of this trial in 1957, and only the sulphate of ammonia treatment (N_2) produced a significant increase in yield of 3.01 cwt. of clean coffee an acre ($p=0.05$).

TABLE XIX
Summary of Yield Response in 1957
(Yields in cwt. clean coffee per acre)

Nitrogenous Fertilizer	Composted Cattle Manure			Means	
	C ₀ . Nil	C ₁ . 1 × 4-gall. tin per tree	C ₂ . 2 × 4-gall. tin per tree		
N ₀ . Nil	21.36	21.02	24.09	22.15	
N ₁ . 46 lb. N. as 100 lb. Urea/acre	20.59	22.10	24.86	22.52	
N ₂ . 46 lb. N. as 224 lb. Sulphate of Ammonia/ acre	25.43	24.42	25.63	25.16	
Means	22.46	22.51	24.86		
C. of V. % = 10.79	Within the table Between marginal means				
Least Significant Difference					
p = 0.05				4.35	2.51
p = 0.01				5.99	3.46
p = 0.001				8.24	4.75

Before concluding that the 1957 results show sulphate of ammonia to be superior to urea as a nitrogen fertilizer for use in coffee it should be recalled that the plots to which the urea was applied had received an annual dressing of only 23 lb. of nitrogen per acre for ten years while the N_2 plots had received 46 lb. of nitrogen a year throughout the same period 1947-1956.

Table XX summarizes the mean annual yield from this trial during the six years 1952-1957. Although the N_1 treatment has led to yields not significantly greater than the unfertilized treatments the N_2 treatment has produced a very highly significant ($p=0.001$) mean annual yield increase of 1.32 cwt. of clean coffee per acre. In the absence of cattle manure this increase is 2.21 cwt./acre ($p=0.01$). Only in the absence of a nitrogenous fertilizer has cattle manure increased the yield of coffee significantly. An annual application of two 4-gallon tins of well-composted cattle manure per tree has raised the mean annual yield by 1.51 cwt. of clean coffee per acre.

TABLE XX
Summary of Yield Responses 1952-1957
(Mean annual yields in cwt. clean coffee per acre)

<i>Nitrogenous Fertilizer per acre per year</i>	<i>Composted Cattle Manure</i>			<i>Means</i>
	<i>C₀. Nil</i>	<i>C₁. 1 4-gall. tin per tree</i>	<i>C₂. 2 4-gall. tins per tree</i>	
N ₀ . Nil	9.20	9.56	10.71	9.82
N ₁ . Until 1957 1 cwt. S/A: From 1957 100 lb. urea	9.96	10.31	10.52	10.26
N ₂ . 2 cwt. Sulphate of Ammonia	11.41	10.62	11.38	11.14
Means	10.19	10.16	10.87	10.41
C. of V. % = 6.62 Least Significant Difference	<i>Within the table</i>		<i>Between marginal means</i>	
p = 0.05	1.19		0.69	
p = 0.01	1.64		0.95	
p = 0.001	2.26		1.31	

MANURIAL TRIAL II

The phosphate treatment was altered in 1957 because in none of the previous seven years of this trial had the crop been increased by the annual application of 2 cwt./acre of double superphosphate. Basic slag was applied in 1957 at the rate of 642 lb./acre to maintain the rate of P₂O₅ dressing while at the same time supplying various minor nutrients.

TABLE XXI
Yield Summary 1950-1957
(Mean annual yields in cwt. clean coffee per acre)

<i>Annual treatments</i>	<i>1957</i>	<i>1950-1957</i>
No Nitrogenous fertilizer	18.92	8.14
92 lb. N/acre per annum	22.95	9.86
% Response	+21.30%	+21.13%
No phosphate fertilizer	21.04	9.14
Equiv. of 2 cwt./acre double Superphosphate	20.83	8.86
% Response	-1.00%	-3.06%
No manure	19.95	8.79
4 × 4-gall. tins manure per tree	21.91	9.21
% Response	+ 9.82%	+ 4.78%
C. of V. % Least Significant Difference	6.53	4.19
p = 0.05	1.62	0.45
p = 0.01	2.39	0.66
p = 0.001	3.69	1.02

Neither in the 1957 yields nor in the mean yields for the eight years 1950-1957 is there any indication of a benefit from phosphatic fertilizers. Cattle manure increased the yield significantly ($p=0.05$) in 1957 but there is no significant difference between the eight-year mean yields. In 1957, 200 lb./acre of urea were applied instead of the 4 cwt. of sulphate of ammonia which had been used for the previous seven years. There was a very highly significant ($p=0.001$) positive response to nitrogen in 1957 and between the yields for the period 1950-1957.

TABLE XXII
Manure × Nitrogen Interaction 1950-1957
(Mean annual yields in cwt. clean coffee per acre)

Annual dressing of cattle manure	Nitrogenous Fertilizer/year		
	Nil	92 lb. N/acre	Effect of Nitrogen
No cattle manure	7.60	9.98	+2.38
4 × 4-gall. tin per tree	8.68	9.74	+1.06
Effect of manure	+1.08	−0.24	
<i>Least Significant Difference</i>			
p = 0.05		0.64	
p = 0.01		0.93	
0 = 0.001		1.44	

The statistical analysis of the yields for the eight crops revealed a negative interaction between nitrogen and cattle manure which reached the 1% level of significance ($p=0.01$). The relevant figures are presented in Table XXII which shows that there was only significant response to cattle manure in the absence of nitrogen, and the response to the fertilizer treatment was more than halved where cattle manure was also applied.

MANURIAL TRIAL III

In 1957 the form of nitrogenous fertilizer used in this trial was changed from sulphate of ammonia to urea, but the quantity of nitrogen applied per acre remained at 46 lb. for N_1 and 92 lb. for N_2 .

TABLE XXIII
Summary of Yield Responses in 1957
(Yields in cwt. clean coffee per acre)

Nitrogen Fertilizer per acre per year	Time of Application			Means	
	T ₀ . Early Long Rains	T ₁ . Early. Short Rains	T ₂ . Half early in each Rains		
N ₀ . Nil	18.83	19.23	20.17	19.41	
N ₁ . 46 lb. N. as 100 lb. urea	23.29	20.85	24.28	22.80	
N ₂ . 92 lb. N. as 200 lb. urea	22.36	23.58	24.51	23.48	
Means	21.49	21.22	22.98	21.90	
C. of V. %=9.62	<i>Within the table</i>			<i>Between marginal means</i>	
<i>Least Significant Difference</i>					
p = 0.05					2.11
p = 0.01					2.90
p = 0.001					3.98

The overall response to nitrogen was considerable in 1957 when the N_1 treatment increased the crop by 3.39 cwt. clean coffee per acre ($p = 0.01$) and the N_2 treatment by 4.07 cwt./acre ($p=0.001$). There was no significant difference between the two rates of fertilizer application, or between the various times of fertilizer application.

TABLE XXIV
Summary of Yield Responses 1952-1957
(Mean annual yields in cwt. clean coffee per acre)

Nitrogenous Fertilizer per acre per year	Time of Application			Means
	T_0 . Early Long Rains	T_1 . Early Short Rains	T_3 . Half early in each Rains	
N_0 . Nil	8.67	8.48	9.02	8.72
N_1 . 46 lb. N.	9.85	9.59	10.31	9.92
N_2 . 92 lb. N.	10.18	10.43	10.28	10.29
Means	9.56	9.50	9.87	9.64
C. of V. $\% = 9.19$ Least Significant Difference $p = 0.05$ $p = 0.01$ $p = 0.001$	Within the table		Between marginal means	
	1.53		0.89	
	2.11		1.22	
	2.90		1.68	

In Table XXIV, which summarizes the results for the six years this trial has run, the responses are very similar to those in the single year 1957. There is no significant difference between the times of fertilizer application, but the fertilizer treatments themselves have produced significant increases in yield of clean coffee. Where 46 lb. of nitrogen has been applied a year the mean annual yield increase has been 1.20 cwt./acre ($p=0.05$) and where double the quantity of nitrogen has been used the increase has been 1.57 cwt./acre ($p=0.01$).

MANURIAL TRIAL IV

In 1957 urea was used for the first time to supply the nitrogen in the fertilizer treatments N_3 (69 lb. N) and N_6 (138 lb. N). Otherwise the treatments were applied as described in the previous Annual Report, page 29.

Results

The responses to the fertilizer treatments of this trial were most valuable in 1957 for, as Table XXV shows, the N_3 treatment led to an increase in yield of 2.29 cwt. of clean coffee per acre ($p=0.05$) and the N_6 application produced 3.78 cwt. more than control ($p=0.01$). It is interesting to see that the highest responses to the nitrogenous fertilizer occurred on the M_2 plots on which bands of mulch $4\frac{1}{2}$ ft. wide applied along the rows of coffee. Of all the mulch treatments receiving fertilizer only this one has led to a significant mean annual yield increase over the four years of this trial.

In 1957 the unmulched plots outyielded all the mulched plots by very substantial margins, and from the mean yields for 1954-1957 (Table XXVII) it may be seen that in this trial the response to mulching has been particularly poor though in the absence of a nitrogenous fertilizer the all inter-row mulch treatment has led to a highly significant yield increase of 3.64 cwt. of clean coffee a year. With nitrogen applied at the rate of 138 lb./acre a year the in-row $4\frac{1}{2}$ -ft. band of mulch treatment (M_2) has given a mean annual increase of 1.60 cwt. an acre (not significant).

Both Tables XXVI and XXVIII show the importance of applying the nitrogenous fertilizer to the bare soil and not scattered over the mulch. This was very marked in 1957 when the bare soil application was highly significantly ($p = 0.01$) more effective than the treatment over the mulch. From the mean yields for the four years it appears that where the lower rate of fertilizer is used it is particularly important to apply it to the soil.

TABLE XXV
Summary of Yield Responses 1957
(Yields in cwt. clean coffee per acre)

lb. Nitrogen per acre per year	Mulch Treatments					Overall means	Least Significant Difference		
	M_0	M_1	M_2	M_3	Between		$p = 0.05$	$p = 0.01$	
	Nil	6 ft. between alternate rows	4½ ft. in all rows	6 ft. between each row					
N ₀ . Nil	a. 15.19	a. 8.75	a. 8.54	a. 8.96	d. 10.36	a. & a. b. & b. a. & b.	4.64 3.30 4.04	6.23 4.43 5.42	
N ₃ . 69	a. 19.84	b. 11.41	b. 12.59	b. 10.35	g. 12.65	c. & c. e. & e.	2.41 1.04	3.23 1.40	
N ₆ . 138	a. 19.94	b. 11.80	b. 16.16	b. 11.58	g. 14.14	d & g. g. & g.	2.07 0.88	2.78 1.19	
Overall Means	c. 18.32	e. 11.04	e. 13.20	e. 10.56					
C. of V. % = 22.15									

TABLE XXVI
The Effect of Fertilizer Placement on Yield Responses in 1957
(Yields in cwt. of clean coffee per acre)

Fertilizer placement	lb. Nitrogen per acre per year			Mean	Least Significant Difference	
	N_3 . 69	N_6 . 138			$p = 0.05$	$p = 0.01$
P_1 . To bare soil	12.60	14.37	13.49	Within the table	1.35	1.81
P_2 . On top of the mulch	10.30	11.98	11.14	Marginal means	0.95	1.28
Mean	11.45	13.18	12.32			

TABLE XXVII
Summary of Yield Responses 1954-1957
(Mean annual yields in cwt. clean coffee per acre)

lb. Nitrogen per acre per year	Mulch Treatments				Overall means	Least Significant Difference		
	M_0 Nil	M_1 6 ft. between alternate rows	M_2 4½ ft. in every row	M_3 6 ft. between all rows		Between	$p = 0.05$	$p = 0.01$
N ₀ . Nil	a. 10.58	a. 11.30	a. 10.90	a. 14.22	d. 11.75	a & a. b. & b. a & b.	1.98 1.41 1.73	2.66 1.89 2.32
N ₃ . 69	a. 11.84	b. 12.19	b. 12.66	b. 12.12	g. 12.25	c. & c. e. & e.	1.03 0.44	1.38 0.60
N ₆ . 138	a. 12.64	b. 11.69	b. 14.24	b. 12.20	g. 12.69	d. & g. g. & g.	0.88 0.38	1.19 0.51
Overall means	c. 11.68	e. 11.81	e. 12.93	e. 12.57				
C. of V. % = 9.93								

TABLE XXVIII
The Effect of Fertilizer Placement on Yield Responses 1954-1957
(Mean annual yields in cwt. clean coffee per acre)

Fertilizer placement	lb. Nitrogen per acre per year		Mean	Least Significant Difference	
	N ₃ . 69	N ₆ . 138		p = 0.05	p = 0.01
P ₁ . To bare soil	13.09	12.96	13.03	0.57	0.77
P ₂ . On top of the mulch	11.55	12.45	12.00	0.41	0.55
Mean	12.32	12.71	12.52		

MANURIAL TRIAL V

Site: Gently sloping area of Kikuyu dark red loam.
Date Planted: 1956.
Spacing: 9 ft. × 9 ft.
Shade: None.
Pruning System: Multiple stem.
Trial Commenced: November, 1957.

Object

To investigate the importance of magnesium and calcium as plant nutrients in the presence and absence of mulch and with and without dressings of a nitrogenous fertilizer.

Layout

A 4 × 3 × 2 factorial design in two blocks of twelve, 16-tree plots with high order interactions confounded and main plots split for the application of hydrated lime. Each main plot is surrounded by guard rows on all sides.

Treatments

Main plots

Magnesium	0	Nil.
	1	$\frac{1}{4}$ lb. Kieserite per tree applied before the Long Rains.
	2	$\frac{1}{2}$ lb. " " " " " " " "
	3	1 lb. " " " " " " " "
Nitrogen	0	Nil.
	1	46 lb. Nitrogen per acre as 100 lb. Urea applied during the Long Rains.
	2	92 lb. Nitrogen per acre as 200 lb. Urea applied during the Long Rains.
Mulch	0	Nil.
	1	A 6-ft. band of mulch 4" deep applied in alternate inter-rows in alternate years.

Sub-Treatment

Calcium	0	No hydrated lime.
	1	1 cwt./acre hydrated lime applied before mulching.

Results

No yields were recorded in 1957.

MANURIAL TRIAL VI

Site: Moderate slope of partially eroded Kikuyu red loam.
Date Planted: Before 1920.
Spacing: 10 ft. $\times$ 10 ft.
Shade: None.
Pruning System: Single stem.
Trial Commenced: 1957.

Object

To compare two types of magnesium fertilizer.

Layout

A 3×3 factorial design in three replications of nine plots each of 20 trees in two rows of ten and surrounded on all sides by guard rows.

Treatments

Kieserite	0	Nil.	
	1	112 lb. per acre.	20 lb. Mg. per acre.
	2	224 lb. per acre.	40 lb. Mg. per acre.
Magnesite	0	Nil.	
	1	70 lb. per acre.	20 lb. Mg. per acre.
	2	140 lb. per acre.	40 lb. Mg. per acre.

The annual application of mulch to all inter-rows and 200 lb./acre of urea are standard treatments in this trial.

Results

No yields were recorded in 1957.

UREA SPRAY TRIAL VII

Site: Moderate slope of Kikuyu red loam.
Date Planted: Before 1920.
Spacing: Approximately 10 ft. $\times$ 10 ft.
Shade: None.
Pruning System: Multiple stem.
Trial Commenced: 1957.

Object

To compare the efficiency and economy of applying urea to coffee as a dry pelleted preparation on the ground or as a foliage spray in a high or low volume of fluid.

Layout

Three randomized blocks of ten, 14-tree, single-row plots.

Treatments

Control : No fertilizer application.

Soil application of 50 lb., 100 lb. and 200 lb. urea per acre.

High Volume Spray : 25 lb., 50 lb. and 100 lb. urea per acre as a 2.5% w/w solution.

Low Volume Spray:

25 lb. urea per acre in 20 galls./water—12.5% w/w solution.

50 lb. urea per acre in 20 galls./water—25.0% w/w solution.

100 lb. urea per acre in 20 galls./water—50.0% w/w solution.

Method of Application

All treatments were applied early in the Long Rains—the second half of April. The prilled urea was scattered around each tree between one and three feet from the stem. A “Salva” bucket pump was used to apply the high volume spray and for these treatments tarpaulins were spread beneath the trees to catch the run-off from the leaves. The low volume treatments were applied with a “Micron Meg” sprayer.

Results

Following the application of the spray treatments no serious leaf scorch was observed though the tips of a few leaves sprayed with the “Micron” showed signs of damage. It had been intended to measure the volume of the spray which ran off the leaves receiving the high volume spray treatments but unfortunately the practical difficulties proved too great and no reasonable estimate could be made.

TABLE XXIX
Summary of Results 1957
(Yields in cwt. clean coffee per acre)

lb. of Urea per acre	Method of Application				Means
	Nil	Dry to the ground	High volume spray	Low volume spray	
Nil	9.13 a.				9.13 a.
25			8.86 a.	11.50 a.	10.18 b.
50		10.24 a.	11.62 a.	10.11 a.	10.66 c.
100		10.02 a.	9.13 a.	11.70 a.	10.28 c.
200		11.35 a.			11.35 a.
Means	9.13 a.	10.54 c.	9.87 c.	11.10 c.	
C. of V. % = 19.73 Least Significant Differences between p = 0.05	a. & a. 3.58	a. & b. 3.10	a. & c. 2.92	b. & c. 2.31	c. & c. 2.07

In the first crop there was no significant difference between the yields from the various treatments, but as the table shows, there was an indication that the ground application of urea and the low volume sprays had had some influence on the level of cropping.

KITALE MULCH AND NITROGEN TRIAL VIII

Site: Level sandy loam—Basement complex.
Date Planted: 1938.
Spacing: 9 ft. × 9 ft.
Shade: Shade.
Pruning System: Multiple stem.
Trial Commenced: 1956.

Object

To determine the yield response of coffee to mulches and a nitrogenous fertilizer on the Basement Complex soil of Kitale.

Layout

A 5 × 5 Latin square with 20-tree plots surrounded on all sides by guard rows.

Treatments

- A. Control.
- B. 168 lb. of urea per acre (5 oz. per tree) applied shortly after the main flowering—April/May.
- C. Napier Grass (*Pennisetum purpureum*) mulch in alternate inter-rows in alternate years applied at the end of the rains—October.
- D. Treatments—B and C together.
- E. Maize stover mulch in alternate inter-rows in alternate years applied in the dry season—January.

Results

TABLE XXX
1957 Yields
(Yield in cwt. clean coffee per acre)
(Derived by dividing the cherry yield by 6)

Treatment	1957
A. Control	6.43
B. Napier grass mulch—October	6.61
C. Urea at 168 lb. acre—April	6.61
D. Napier grass mulch October and Urea at 168 lb. acre April	6.30
E. Maize Stover mulch—January	6.20
C. of V. %	27.29
Least Significant Difference $p = 0.05$	2.41

The first yields were recorded in 1957 and, as the table shows, there was no detectable difference between treatments.

PRUNING TRIAL I

1957 was the last year of the second multiple-stem cycle since this trial began in 1946. During the first cycle (1946-1951) the multiple-stem trees outyielded all the single-stem treatments, but very poor crops were picked from the multiple-stem trees in 1952 and 1953, while the single-stem trees yielded over a ton to the acre in 1953 and in alternate years have done the same ever since. The present position is summarized in Table XXXI.

TABLE XXXI
Summary of Results 1946-1957
(Mean annual yields in cwt. clean coffee per acre)

Period	A Multiple stem 3 heads	B Single stem capped once	C Single stem capped thrice	D Single stem 2 stems	C. of V. %	Least Significant Difference	
						$p = 0.05$	$p = 0.01$
1946-1951 1st Multiple-Stem cycle	6.69	5.24	4.90	5.81	7.7	0.60	0.80
1957	15.21	22.07	20.07	20.36	16.2	3.87	5.35
1952-1957 2nd Multiple-Stem cycle	8.12	11.20	10.50	10.67			

It is clear that while the multiple-stem trees have produced somewhat more coffee between 1952-1957 than during the years 1946-1951 the yield from the single-stem trees during the last six years has been more than double that in the previous six years.

PRUNING TRIAL II

Site: Level area of Kikuyu dark red loam.
Date Planted: 1956.
Spacing: 9 ft. $\times$ 9 ft.
Shade: None.
Pruning: Under test.
Trial Commenced: 1957.

Object

To study different methods of multiple-stem pruning with particular reference to the control of secondary growth and the amount of bearing wood.

Layout

Two replications of a 4 $\times$ 4 factorial design with main plots split twice. Main plots of a single row of 24 trees.

Treatments

Main plots

Length of head L₀ Primaries cut up to 6" above the "break".
 L₁ Primaries cut up to the "break".
 L₂ Primaries cut up to 6" below the "break".
 L₃ Primaries cut up to 12" below the "break".

The "break" is the point on the stem of a coffee tree pruned on the multiple-stem system above which primaries have only borne one crop while below it the primaries have carried two crops.

Control of Secondary Growth

S₀ All secondaries within 18" of the main stem removed at pruning.
 S₁ All secondaries removed except the two terminal pairs of secondaries or secondaries within 12" of the terminal bud of each primary.
 S₂ All secondaries removed at pruning.
 S₃ All secondaries removed throughout the year.

(Extra Treatment

LiSx All secondaries decropped.)

Sub-plots

+D All crop removed until the flowering 28 months from planting.
 -D No decropping.

Sub-sub-plots

H₁ One head only for the first five or six years.
 H₂ Two heads for the first cycle of six-seven years.

Of the above treatments only those applicable to the sub-plots and the sub-sub-plots were carried out in 1957 since the trees were still too small for the main treatments to be performed realistically.

COPPER AND NON-COPPER SPRAY TRIAL

The highest yields in 1957 were recorded from the plots sprayed with "Perenox" (6.8 lb./100 galls.) at a pint per tree late in the Long Rains (May) and early in the Short Rains (October). The yields from this treatment were significantly greater than those from any of the other treatments, and all treatments, except the hormone spray, produced very highly significantly ($p = 0.001$) more crop than the control treatment which was unsprayed.

TABLE XXXII
Summary of Yields 1955-1957
(Mean annual yields in cwt. clean coffee per acre)

<i>Treatment</i>	<i>1957</i>	<i>1955-1957</i>
Control: No spray	5.60	6.33
"Perenox," May	11.06	9.97
"Perenox," May + October	14.38	10.97
"Fernide," early middle and late Long Rains	11.94	10.50
"Cuprosana" dust	9.17	9.15
"Anapal" hormone spray	5.84	7.39
C. of V. % = 9.78		
<i>Least Significant Difference</i>		
p = 0.05	1.42	
p = 0.01	1.97	
p = 0.001	2.72	

This trial received its final application of copper, non-copper and hormone sprayings and copper dustings.

"Perenox" treatments in 1957 showed a good control of leaf-fall but there was no appreciable difference between the two sprayings in May and October and the single spraying in May, thus confirming the timing always advocated.

The hormone spray and "Cuprosana" dusting were the least effective—being practically on a level with the non-sprayed trees' leaf-fall. "Fernide", as always, produced the best control except during the Long Rains when trees so treated shed more than all others in the experiment, including the controls.

A Rust count showed that those trees retaining their foliage best obviously had the highest infection.

The 1957 yield records of cherry and clean coffee showed a considerable correlation with the leaf-fall—the "Perenox" and "Fernide" treatments being well ahead with the hormone only just above the control. Even with considerably increased applications of "Cuprosana" dust, the crop on these trees was still far short of the three best treatments.

The mean annual yields for 1955-1957 show that treatments with both the copper fungicides "Perenox" and "Cuprosana" and the copper-free fungicide "Fernide" have produced substantially more coffee than the hormone or the unsprayed treatments.

MACHINE SPRAY TRIAL I

In 1957 the unsprayed plots yielded at less than 2 cwt. of clean coffee per acre following the crop of 14.84 cwt. they carried in 1956. The sprayed plots carried a moderate crop and this demonstrates one benefit of copper spraying, which is to reduce the range of the biennial bearing characteristic.

TABLE XXXIII
The Effect of Copper Sprays in Reducing Biennial Bearing
(Mean annual yields in cwt. clean coffee per acre)

	<i>1955</i>	<i>1956</i>	<i>1957</i>	<i>3-year mean</i>
Sprayed treatments	9.93	12.28	6.08	9.43
Unsprayed	3.03	14.84	1.96	6.61

TABLE XXXIV
Yield Summary 1954-1957
(Mean annual yields in cwt. clean coffee per acre)

<i>lb. of 50% Copper formulation/100 gallons</i>	<i>Galls. per acre</i>	<i>Sprayer</i>	<i>1957</i>	<i>3-year mean</i>
Nil	—	—	1.96	6.61
6.8	30	Agro Airblast	6.00	9.24
6.8	60	" "	6.17	8.92
13.6	30	" "	6.65	9.69
13.6	60	" "	4.28	9.14
6.8	120	Quadrex "S"	7.32	10.15
C. of V. % Least Significant Difference			33.36	6.10
p = 0.05			2.71	0.21
p = 0.01			3.75	0.28
p = 0.001			5.19	0.39

TABLE XXXV
Concentration × Volume Interaction
(Mean annual yields for 1954-1957 expressed as a percentage of the control treatment)

<i>lb. of 50% Copper formulation/100 gallons</i>	<i>Gallons of spray per acre</i>				<i>Mean</i>
	<i>Nil</i>	<i>30</i>	<i>60</i>	<i>120</i>	
Nil	100				100
6.8		140	135	154	143
13.6		145	138		142
	100	143	137	154	

In the 3-year mean yields the high volume Quadrex "S" treatment is shown to be superior to all other treatments. At either concentration of copper fungicide the Agro Airblast has been more effective at 30 gallons per acre than at 60 gallons per acre and at both gallonages the higher concentration has been slightly superior to the lower.

MACHINE SPRAY TRIAL II

The yields were first recorded from this trial in 1957 but there was no significant difference between treatments.

TABLE XXXVI
1957 Yields
(Yields in cwt. clean coffee per acre)

<i>lb. 50% copper formulation 100/galls.</i>	<i>Galls. per acre</i>	<i>Sprayer</i>	<i>Yield</i>
Nil	—	—	5.25
6.8	60	Agro Airblast	5.08
6.8	10	Micron Meg.	4.84
13.6	10	" "	6.74
34.0	10	" "	6.45
C. of V. % = 22.00 Least Significant Difference p = 0.05			1.92

The absence of a considerable yield response is remarkable, for in the many trials of this type which have been carried out in recent years the most marked yield increases have been recorded from the crop ripening a year after the first spray application. This trial was commenced in May, 1956, and the initial sprays succeeded in reducing the loss of leaf from the coffee trees (1956/57 Annual Report, p. 38). It was therefore expected that in 1957 the sprayed plots would yield more than the unsprayed, but this was not the case. During 1957 the coffee of the block in which this trial is situated was seriously attacked by Leafminer and early in the maturation of the crop there was a considerable shedding of green berries which was said to have been induced by damage caused by female Fruitfly. It seems possible, therefore, that the effect of these insect pests completely masked any yield responses there may have been.

KITALE AND MAKUYU SPRAY TRIALS

The results from these trials continue to show that May is the best time for spraying with copper to reduce leaf-fall.

At Kitale, where there is one rains period only, the late rains spray (August) is significantly less effective than the May or mid-rains treatment, though over the six years 1952-1957 all spray treatments have increased the yield of coffee.

TABLE XXXVII
Kitale Spray Trial
Summary of Results 1952-1957
(Mean annual yields in cwt. clean coffee per acre)
(The weight of clean coffee has been obtained by dividing the cherry weight by 6)

Period	Time of Spraying				C. of V. %	Least Significant Difference		
	No spray	May	June	August		$p = 0.05$	$p = 0.01$	$p = 0.001$
1957	6.26	7.82	7.28	6.30	22.66	1.33	1.79	2.38
1952-1957	6.75	8.52	8.16	7.76	10.54	0.69	0.93	1.23

TABLE XXXVIII
Makuyu Spray Trial
Summary of Results 1955-1957
(Mean annual yields in cwt. clean coffee per acre)

Period	Time of Spraying				C. of V. %	Least Significant Difference		
	No spray	Early Long Rains April	Late Long Rains late May	Early Short Rains Nov.		$p = 0.05$	$p = 0.01$	$p = 0.001$
1957	5.39	8.64	7.90	8.44	14.86	1.81	2.59	3.81
1955-1957	5.40	7.56	7.57	6.91				

At Makuyu there are two distinct rains periods and although all three times appear effective for spraying, the Long Rains (April-May) treatments produced greater yield increases than the Short Rains sprays (November).

GENERAL COFFEE CULTURE TRIAL

<i>Site:</i>	Slightly sloping area of Kikuyu dark red loam.
<i>Date Planted:</i>	1956.
<i>Spacing:</i>	9 ft. $\times$ 9 ft.
<i>Shade:</i>	None.
<i>Pruning:</i>	Multiple stem.
<i>Trial Commenced:</i>	1957.

Object

To test the interactions of the various recommended cultural practices and those generally carried out by the indifferent though not bad coffee-grower.

Layout

Two replications of a 2⁵ factorial design. Each plot consists of two rows of eight trees and is surrounded on all sides by guard rows.

Treatments

- ±a Alternate inter-rows mulched in each year.
Note: The —a plots were mulched in the tree rows for the first year from planting.
The +a plots are to be mulched in every tree row for three years from planting.
- +b Clean weeding at all times.
- b Weeds slashed during the rains, and the plots clean weeded during the dry seasons.
- ±c A fungicide spray applied in May to reduce leaf-fall—from 1958.
- ±d Nitrogenous fertilizer.
- ±e Spare treatment.

VARIETY TRIALS

In 1950 a coffee variety trial programme was initiated to cover the whole Colony so that information might be collected on the performance of the improved coffee selections under widely varying ecological conditions typical of Kenya. This scheme is closely integrated with the expansion of African coffee-growing, but although a large number of trials are situated in the Reserves the information obtained will often be applicable to neighbouring European areas. The location of the various trials may be summarized as follows :—

Variety Trials in European Areas

- i. Trial I, at the Coffee Research Station, Ruiru, planted in 1950.
- ii. Trial II, at the Coffee Research Station, Ruiru, planted in 1951.
- iii. Makuyu Coffee Research Sub-station—
Six varieties in five randomized blocks planted in 1953.
- iv and v. Kentmere Estate, Upper Kiambu—
Trial I : 16 varieties in a 4 $\times$ 4 balanced lattice planted in 1954.
Trial II : Nine varieties in a 3 $\times$ 3 balanced lattice planted in 1954.
- vi. Kitale Coffee Research Sub-station—
16 varieties in a 4 $\times$ 4 balanced lattice planted in 1954.
- vii. Scott Agricultural Laboratories, Kabete—
Nine varieties in six randomized blocks planted in 1956.

Variety Trials in African Areas

Two types of trials have been laid down in these areas. The first is a major yield recorded trial with individual plots of between six and ten trees, and the second, which is far more numerous, consists of single-tree plots arranged in 5 $\times$ 5, 6 $\times$ 6 or 7 $\times$ 7 Latin squares. These latter trials are used to extend the detailed large trials to nearby areas of varying ecology.

(a) Large trials having plots of between six-ten trees.

- i. South Nyanza—Kisii : 7 $\times$ 7 Latin square planted in 1950.
- ii. Teita—Wundanyi : 6 $\times$ 6 Latin square planted in 1951.
- iii. Meru—Meru : 5 $\times$ 5 Latin square planted in 1951.
- iv. Chogoria : 5 $\times$ 5 Latin square planted in 1951.
- v. Embu—Embu Investigation Centre : 5 $\times$ 5 Latin square planted in 1951.

vi. Kerugoya : 5 × 5 Latin square planted in 1951.

vii and viii. North Nyanza-Shikusa : two 7 × 7 Latin squares, one of which includes cultural treatments, planted in 1954.

(b) Miniature Trials having single-tree plots.

Nyanza Province	.	.	.	44 trials.
Central Province	.	.	.	29 „
Southern Province	.	.	.	25 „
Rift Valley Province	.	.	.	14 „
Coast Province	.	.	.	2 „

In the results of the variety trials summarized in this section it is important to distinguish between the large trials and the miniature trials, because in the case of the latter the coefficients of variation for single-year results are often so great as to render any deductions hazardous. However, when yields are available for several years it is possible to gain a useful amount of information on the performance of each selection under various ecological conditions.

For ease of reference the results are grouped by districts and in each group the yields of the large trials precede those of the miniature variety trials.

CENTRAL PROVINCE: COFFEE RESEARCH STATION, RUIRU VARIETY TRIALS I AND II

Altitude: 5,400.

Rainfall: 36 inches.

Spacing: 9 ft. × 9 ft.

Five crops have now been recorded for Variety Trial I which was planted in 1950. In general the Scott Laboratory (SL) selections have outyielded those made on Kitamaiyu Estate. SL.30

TABLE XXXIX
Summary of Results
(Mean annual yields in cwt. clean coffee per acre)

Variety Trial I 1953-1957			Variety Trial II 1954-1957		
Variety	1957 yields	5-year mean yields	Variety	1957 yields	4-year mean yields
SL.28	18.00	11.11	N.218	18.55	13.39
SL.19	18.63	10.96	Dalle Mixed	18.70	12.93
SL.14	14.04	10.67	SL.34	14.50	12.41
SL.30	8.64	9.60	K.7	15.46	10.93
SL.17	13.50	9.28	SL.9	14.74	10.74
KIT.251	14.06	9.06	M.6	11.12	10.13
SL.1	12.92	9.00	Series L	15.77	10.10
KIT.107	11.50	8.72	Kenya Selected	15.48	10.04
KIT.37	11.32	8.72	M.83	9.84	9.95
KIT.27	8.91	8.62	SL.2	11.18	9.81
KIT.85	8.52	8.34	SL.28	13.02	9.74
KIT.13	10.88	8.31	Mocha	10.81	9.38
KIT.145	9.69	7.99	M.65	11.72	9.35
KIT.106	7.76	7.95	Kents	13.88	9.17
KIT.64	5.83	7.78	N.100	10.19	9.10
KIT.109	6.43	7.27	SL.10	9.04	9.09
C. of V. % = 17.83 <i>Least Significant Difference</i> p = 0.05 p = 0.01			SL.18	11.91	8.72
			KP.532	12.97	8.57
			Dilla and Alghe	11.97	8.25
	2.88		SL.6	14.96	7.94
	3.85		M.48	11.26	7.85
			C. of V. % = 15.72 <i>Least Significant Difference</i> p = 0.05 p = 0.01	2.87 3.81	

was superior to most other selections for the first four crops but its acute susceptibility to Leaf Rust resulted in the 1957 yield being one of the lowest recorded. SL.38, SL.19 and SL.14 continue to occupy leading positions in the yield table.

Variety Trial II was planted a year after Variety Trial I, and thus has produced four recorded crops. N.218 selected in Tanganyika has shared the leading position in this trial with Dalle Mixed which was collected in Ethiopia and the Kenya selection SL.34. In 1957, following a series of years in which Leaf Rust had been serious, the varieties having some resistance to this disease yielded particularly well. The varieties are K.7 (15.46 cwt.), SL.6 (14.96 cwt.), Kents (13.88 cwt.), KP.532 (12.97 cwt.) and Dilla and Alghe (11.97 cwt.).

CENTRAL PROVINCE: NORTH KITITO ESTATE MAKUYU VARIETY TRIAL

Altitude: 4,800. *Rainfall:* 36 inches.
Date Planted: 1953.
Spacing: 9 ft. × 9 ft.

LAYOUT

A randomized block design with five replications of six varieties—Single-row plots of 20 trees each.

RESULTS

TABLE XL
Summary of Yields 1956-1957
 (Mean annual yields in cwt. clean coffee per acre)

<i>Variety</i>	<i>1956</i>	<i>1957</i>	<i>1956-1957</i>
SL.28	17.94	13.12	15.53
Meru Kents	15.07	10.62	12.85
SL.14	14.43	9.77	12.10
K.7	14.43	9.55	11.99
Kenya Selected (Series A)	14.08	9.51	11.80
SL.9	13.18	10.31	11.75
C. of V. %	24.72	9.55	6.32
<i>Least Significant Difference</i>			
p = 0.05	4.42	1.20	2.41
p = 0.01	6.03	1.64	3.29
p = 0.001	8.16	2.22	4.45

The yield from the first two crops from this trial show that SL.28 significantly outyielded SL.9 in 1956 and K.7 and Kenya Selected (Series A) in 1957. In the mean yields for the two years it may be seen that SL.28 significantly outyielded all other varieties under trial amongst which there was no significant difference in yield.

CENTRAL PROVINCE: MERU DISTRICT MERIGA MIERU VARIETY TRIAL (MERU SEED FARM)

Altitude: 5,500. *Rainfall:* 53 inches.
Date Planted: 1951.
Spacing: 9 ft. × 9 ft.

Layout

A 5 × 5 Latin square with nine-tree plots.

Results

TABLE XLI
Meriga Mieru Variety Trial 1954-1957
(Mean annual yields in cwt. clean coffee per acre)
(Derived by dividing cherry yields by 6)

Variety	1957			1954-1957
	1st crop	2nd crop	Total	
SL.28	7.46	0.87	8.33	16.38
SL.34	7.71	2.17	9.88	16.22
Kenya Selected	7.30	1.51	8.81	14.94
N.100	5.13	0.57	5.70	12.11
Meru Kents	3.71	2.52	6.23	10.47
C. of V. %	42.39	74.30	30.46	
Least Significant Difference				
p = 0.05	3.64	1.56	3.26	
p = 0.01	5.13	2.19	4.58	

Following the heavy yields of 1956-57 the 1957-58 crop was quite moderate and did not affect the ranking of the varieties in the mean yield for the period 1954-1957. In the total crop for 1957-58 SL.34 significantly outyielded N.100 and Meru Kents ($p=0.05$).

CENTRAL PROVINCE: MERU DISTRICT KIRIANI VARIETY TRIAL (CHOGORIA)

Altitude: 5,100.

Rainfall: 62 inches.

Date Planted: 1951.

Spacing: 9 ft. × 9 ft.

Layout

A 5 × 5 Latin square with nine-tree plots.

Results

TABLE XLII
Kiriani Variety Trial 1954-1957
(Mean annual yields in cwt. clean coffee per acre)
(Derived by dividing cherry yields by 6)

Variety	1957			1954-1957
	1st crop	2nd crop	Total	
SL.18	3.01	0.49	3.50	14.52
SL.9	1.79	0.59	2.38	13.64
Meru Kents	10.05	1.68	11.73	13.23
SL.28	1.29	0.59	1.88	12.81
Mocha	0.67	0.02	0.69	9.00
C. of V. %	24.28	51.12	8.78	
Least Significant Difference				
p = 0.05	1.12	0.47	0.45	
p = 0.01	1.58	0.67	0.64	

Following the high yields of 1956-57 the level of cropping in the 1957-58 season was low with the notable exception of Meru Kents. Hitherto this type has not shown up well in variety trials but in both the first and second crops picked from this trial in 1957-58 it has significantly outyielded all other varieties. Nevertheless, SL.18 still heads the table of mean yields for four years 1954-1957.

CENTRAL PROVINCE: EMBU DISTRICT EMBU INVESTIGATION CENTRE VARIETY TRIAL

Altitude: 4,800.
Date Planted: 1950.
Spacing: 9 ft. $\times$ 9 ft.

Rainfall: 41 inches.

Layout

A 5 $\times$ 5 Latin square with nine-tree plots.

Results

TABLE XLIII
Embu Investigation Centre Variety Trial 1953-1957
(Mean annual yield in cwt. clean coffee per acre)
(Derived by dividing the cherry yield by 6)

<i>Variety</i>	<i>1957</i>	<i>1953-1957</i>
SL.14	5.73	12.79
SL.34	4.43	12.53
SL.28	3.72	11.99
N.197	3.68	10.88
Kents	3.61	10.46
C. of V. % = 21.59		
<i>Least Significant Difference</i>		
p = 0.05	1.26	
p = 0.01	1.77	

The differences between varieties in this trial continue to be rather slight. In 1957 the only significant difference was between SL.14 and all other varieties. SL.14 now occupies the leading position in the mean annual yields for the five crops so far recorded. There is, however, little difference between the yields of the three SL. selections.

CENTRAL PROVINCE: MERU DISTRICT KIGUCHWA VARIETY TRIAL (TIGANIA)

Altitude: 4,700.
Date Planted: 1951.
Spacing: 9 ft. $\times$ 9 ft.

Rainfall: 46 inches.

Layout

A 5 $\times$ 5 Latin square with single-tree plots.

Results

TABLE XLIV
Kiguchwa Variety Trial 1955-1957
 (Mean annual yields in cwt. clean coffee per acre)
 (Derived by dividing cherry yield by 6)

Variety	1957	1955-1957
SL.28	31.80	16.01
SL.9	25.57	14.79
N.100	16.78	11.16
SL.34	17.01	9.49
Meru Kents	14.86	8.23
C. of V. % = 41.07		
Least Significant Difference		
p = 0.05	11.95	
p = 0.01	16.83	

The level of cropping on this trial in 1957 was far too high and it is unlikely that the trees are capable of carrying such a crop without sustaining permanent damage. SL.28 clearly outyielded Meru Kents, SL.34 and N.100, but no other difference attained statistical significance in 1957. The mean yields for the three years 1955-1957 are in the same order as those for 1957.

CENTRAL PROVINCE: MERU DISTRICT KAJIANDUTHI VARIETY TRIAL (MUTHAMBI)

Altitude: 4,600.
 Date Planted: 1951.
 Spacing: 9 ft. $\times$ 9 ft.

Rainfall: 56 inches.

Layout

A 5 $\times$ 5 Latin square with single-tree plots.

It is only recently that the yields from this trial have become available for analysis. They are therefore presented in full in the table. SL.28 and Meru Kents have been the outstanding varieties so far and Mocha has produced the least coffee. SL.18 appears to produce the majority of its coffee in the first crop each year while the production of SL.28 and Meru Kents is more evenly spread between the first and the second crops.

Results

TABLE XLV
Kajianduthi Variety Trial 1954-1957
(Mean yields in cwt. clean coffee per acre)
(Derived by dividing cherry yield by 6)

Variety	1954			1955			1956			1957		Mean crop	
	1st crop	2nd crop	Total	1st crop	2nd crop	Total	1st crop	2nd crop	Total	1st crop	2nd crop	1st crops	2nd crops
SL.28	6.89	9.81	16.70	13.30	11.26	24.56	2.50	2.44	4.94	15.17	7.76	9.46	7.76
Meru Kents	3.97	10.58	14.55	14.14	7.97	22.11	4.18	2.05	6.23	18.36	6.80	10.16	6.80
SL.18	5.53	3.47	9.00	21.03	2.49	23.52	7.99	3.11	11.10	12.16	3.00	11.68	3.00
Series L.	2.74	10.02	12.76	14.59	6.25	20.84	3.90	2.01	5.91	12.83	6.03	8.52	6.03
Mocha	4.56	6.06	10.62	10.22	5.09	15.31	2.68	3.90	6.58	6.82	4.97	6.07	4.97
C. of V. %	41.95	78.61		51.00	70.91		110.49	138.24		45.65	57.42	36.99	57.42
Least Significant Difference	2.21	6.99		8.32	5.22		5.22	4.16		6.64	4.52	4.68	4.52
p = 0.05	3.07	9.70		11.54	7.25		7.25	5.77		9.21	6.36	6.59	6.36
p = 0.01													

CENTRAL PROVINCE: MERU DISTRICT NGERU VARIETY TRIAL (LOWER MWIMBE)

Altitude: 4,400.
Date Planted: 1954.
Spacing: 9 ft. $\times$ 9 ft.

Rainfall: 50 inches.

Layout

A 7 $\times$ 7 Latin square with single-tree plot.

Results

TABLE XLVI
Ngeru Variety Trial 1957
(Yields in cwt. clean coffee per acre)
(Derived by dividing cherry yields by 6)

Variety	1957		
	1st crop	2nd crop	Total
Series L	0.83	9.80	10.63
Kenya Selected	1.52	7.41	8.93
SL.28	1.28	4.16	5.44
SL.14	1.30	2.44	3.74
K.7	2.39	1.26	3.66
Barbuk Forest	0.07	0.52	0.59
Columnaris	0.21	0.00	0.21
C. of V. %	142.32	88.41	83.19
Least Significant Difference			
p = 0.05	1.61	3.26	4.45
p = 0.01	2.17	4.29	5.37

The first crops were picked from this trial in 1957/58 and, as the table shows, neither the varieties Columnaris nor Barbuk Forest were in bearing at this time. Series L outyielded all other varieties in the trial, but the coefficients of variation are so high that it would be unwise to form conclusions from this single year's results.

NYANZA PROVINCE: SOUTH NYANZA KISII FARM VARIETY TRIAL

Altitude: 5,600.
Date Planted: 1950.
Spacing: 9 ft. $\times$ 9 ft.

Rainfall: 67 inches.

Layout

A 7 $\times$ 7 Latin square with nine-tree plots.

Results

TABLE XLVII
Kisii Farm Variety Trial 1953-1957
(Mean annual yields in cwt. clean coffee per acre)
(Derived by dividing the cherry yield by 6)

Variety	1957	1953-1957
SL.28	5.57	6.71
SL.14	5.30	6.38
Thorolds	5.38	5.56
Kenya Selected	5.11	5.52
Kents	4.92	5.09
Blue Mountain	4.55	4.78
KIT.145	3.42	4.60
C. of V. %	22.69	
Least Significant Difference		
p = 0.05	1.21	
p = 0.01	1.63	

In 1957 yields were low and did not alter the fact that over the five crops recorded from this trial the selections SL.28 and SL.14 have outyielded all others under trial. The yields from Blue Mountain and KIT.145 have been particularly disappointing.

NYANZA PROVINCE: SHIKUSU VARIETY AND PRUNING TRIAL

Altitude: 5,000. *Rainfall:* 70 inches.
Date Planted: 1954.
Spacing: 9 ft. $\times$ 9 ft.

Object

To compare seven coffee varieties under conditions at Shikusu when pruned according to three systems of secondary control.

Layout

Main Treatments: Seven varieties arranged in a 7×7 Latin square with nine trees per plot.

Sub-Treatments: Three methods of controlling secondary growth. Each main plot being divided into three sub-plots of three trees each.

R: Secondary growth removed at all times.

J: Secondary growth removed for the first crop on each primary and then allowed to remain for the second crop in the following year.

C: Secondary growth removed at all times from the proximal 12 inches of each primary.

Results

TABLE XLVIII
Shikusu Variety $\times$ Pruning Trial 1957
 (Mean yields in cwt. clean coffee per acre)
 (Derived by dividing cherry yields by 6)

<i>Variety</i>	<i>1957</i>	<i>Pruning Treatment</i>	<i>1957</i>
SL.2	3.77	R. All secondary growth removed	2.60
SL.14	3.40		
SL.34	3.21		
SL.28	3.13	J. Secondaries removed for first crop of each primary	2.79
Kapretwa Series A	3.11		
Kents	2.91	C. Secondaries removed from proximal 12 inches of each primary	2.99
SL.30	0.00		
C. of V. %	52.23		30.77
Least Significant Difference			
p = 0.05	1.59		0.34

While there was no significant difference between varieties in their first year of cropping, the pruning treatment C, in which there is the least amount of secondary reduction, yielded 0.39 cwt. of clean coffee an acre more than the severe treatment R ($p=0.05$). The SL.30 trees were so severely attacked by Leaf Rust during the previous years of this trial that many of them died. This variety has now been replaced by the selection K.7 which has yet to carry its first crop.

NYANZA PROVINCE: ELGON NYANZA DISTRICT KAPSAKWONYI VARIETY TRIAL

Altitude: 6,000.
Date Planted: 1954.
Spacing: 9 ft. $\times$ 9 ft.

Rainfall: 50 inches.

Layout

The design of this trial was not laid down by the Coffee Research Station, and although it appears that it was intended to be a 6 $\times$ 6 Latin square this is not in fact the case. It has therefore been analysed as a randomized block design with six replications of six varieties. There is one tree per plot.

Results

TABLE XLIX
Kapsakwonyi Variety Trial 1957
(Mean yields in cwt. clean coffee per acre)
(Derived by dividing cherry yield by 6)

<i>Variety</i>	<i>1957</i>
K.7	6.73
SL.30	5.09
Kapretwa Series A	4.87
SL.14	4.47
SL.2	2.92
SL.34	2.22
C. of V. %	97.41
<i>Least Significant Difference</i> $p = 0.05$	4.95

There is no significant difference between the yields of the six varieties in their first year of bearing.

NYANZA PROVINCE: ELGON NYANZA DISTRICT SICHEI VARIETY TRIAL

Altitude: 5,200.
Date Planted: 1954.
Spacing: 9 ft. $\times$ 9 ft.

Rainfall: 40 inches.

Layout

The design of this trial was not laid down by the Coffee Research Station and the type of analysis intended is not clear from the layout. It has been analysed here as a randomized block design with seven replications of seven varieties. There is one tree per plot.

Results

TABLE L
Sichei Variety Trial 1957
(Mean yields in cwt. clean coffee per acre)
(Derived by dividing cherry yield by 6)

<i>Variety</i>	<i>1957</i>
K.7	9.66
SL.28	7.84
SL.14	7.30
Kapretwa Series A	7.15
Kents	6.93
SL.2	5.79
SL.30	2.47
C. of V. %	53.54
<i>Least Significant Difference</i>	
p = 0.05	1.24
p = 0.01	1.66

In the first year of cropping the yield from K.7 has been highly significantly ($p=0.01$) greater than any other in the trial. SL.2 and SL.30, which are known to be very susceptible to Leaf Rust, have yielded significantly less than any other variety. These results suggest that the limiting factor to the production of high yields in this area is Leaf Rust.

NYANZA PROVINCE: ELGON NYANZA DISTRICT BUTONGE VARIETY TRIAL

Altitude: 4,900. *Rainfall:* 40 inches.
Date Planted: 1955.
Spacing: 9 ft. $\times$ 9 ft.

Layout

The design of this trial was not laid down by the Coffee Research Station; it is systematic and thus it is not correct to carry out the statistical analysis of the results. Nevertheless the yield results for 1957 have been analysed as though the design was of seven varieties in seven randomized blocks. There is one tree per plot.

Results

TABLE LI
Butonge Variety Trial
(Mean yields in cwt. clean coffee per acre)
(Derived by dividing cherry yield by 6)

<i>Variety</i>	<i>1957</i>
K.7	11.50
Kapretwa Series A	10.22
SL.28	9.21
SL.14	8.71
SL.2	4.99
SL.30	4.24
Barbuk Sudan	3.60
C. of V. %	77.70
<i>Least Significant Difference</i>	
p = 0.05	6.34
p = 0.01	8.51

Within two years of planting the trees of this trial have been permitted to carry a very considerable crop. K.7 produced 11.50 cwt. of clean coffee per acre which was significantly greater than that of SL.2, SL.30 or Barbuk Sudan. Only two of the seven Barbuk Sudan trees carried any crop and these in fact yielded at the rate of about 10 cwt./acre. Since the nil yields from the other trees might have been the result of their presence in a non-bearing condition or their death, it was not considered realistic to weight the yields according to the number of bearing trees until further information has been obtained.

COAST PROVINCE: WUNDANYI VARIETY TRIAL

Altitude: 5,400.
Date Planted: 1950.
Spacing: 9 ft. × 9 ft.

Rainfall: 53 inches.

Layout

A 6 × 6 Latin square with six trees per plot.

TABLE LII
Wundanyi Variety Trial 1954-1957
 (Mean annual yields in cwt. clean coffee per acre)

<i>Variety</i>	<i>1957</i>	<i>1954-1957</i>
K.7	7.90	10.60
Kents	7.02	10.43
SL.34	9.40	10.36
KP.532	9.37	10.17
SL.28	7.90	10.05
SL.14	9.42	9.25
C. of V. %	31.10	
<i>Least Significant Difference</i> p = 0.05	3.18	

There was no significant difference between the yields of the six varieties in 1957 and as the four-year mean yields show, there has been little difference between the yields throughout the course of the trial.

AGRICULTURAL CHEMISTRY

SOIL NITROGEN AND RELATED STUDIES

At the end of 1957 the two experiments previously described in the 1956 report were concluded, i.e. No. I, an experiment to compare the mineralization of ammoniacal and nitrate nitrogen fertilizers in the presence and absence of a mulch cover but without the complicating presence of a coffee crop: No. II, an experiment to study the influence of nitrogen fertilizers and mulch on growth, leaf nitrogen content and crop yield.

Sufficient information has now been obtained from the work carried out since 1954 to make possible a description of the natural ammonia and nitrate nitrogen trends in relation to season and temperature, growth and normal cropping periods of the coffee. The influences of mulches and nitrogen fertilizer applications upon these natural trends have also been studied.

Particular emphasis have been placed upon a study of the relationship between mulch, soil and fertilizer nitrogen, and although changes and variations in the soil nitrate and ammonia have been followed and compared, a full explanation of the relationships observed is by no means complete yet.

A comparison of the mineralization of ammoniacal and nitrate nitrogen fertilizers in a mulched fallow coffee soil. (Experiment No. I.)

The intervals between soil samplings in this experiment were not regular. During the two main rain periods sampling was carried out at intervals comparable with laboratory incubation studies. These periods were linked together by occasional spot samplings during the intervening dry weather.

The substantial amount of nitrate nitrogen ($\text{NO}_3\text{-N}$) and ammonia nitrogen ($\text{NH}_3\text{-N}$) data accumulated has been processed statistically in the following manner: Detailed statistical analysis has been made on the figures for samples taken after the application of fertilizers during the rain periods. All the data obtained from every individual sampling made was then weighted for depth, i.e. samples were taken at 0-3", 3-6" and 6-12", at each sampling time and analysed on a cumulative basis. Weighted mean data for individual sampling intervals have been graphed, together with soil moisture and rainfall. It is considered that important treatment trends and differences are suitably expressed by these methods of presentation.

The cumulative $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ figures expressed on a weighted mean basis over the whole experimental period are summarized in Table LIII.

TABLE LIII
A summary of cumulative main treatment effects and interactions for the
experimental period 11.5.56-6.1.58*

Treatments		(1)	Ammonium sulphate	Sodium nitrate	Means
(1)	a.	13.1 (2)	27.4	35.0	25.2 (6)
	b.	3.8	10.8	3.7	6.1
Napier grass mulch	a.	18.0	24.0	29.3	23.8
	b.	4.2	6.0	3.9	4.7
Stone mulch	a.	10.1	17.3	19.9	15.8
	b.	3.7	6.6	4.2	4.8
Means	a.	13.7 (6)	22.9	28.1	L.S.D.s (Means of 6) 5.6*; 8.1** N.S.
	b.	3.9	7.8	3.9	
L.S.D.s (Means of 2)	a.	10.1*;	14.8**		
	b.	N.S.			

Notes: 1. *Weighted mean data for 2 absolute replications over 3 depths for 30 sampling times.
2. a = $\text{NO}_3\text{-N}$ data: b = $\text{NH}_3\text{-N}$ data.
3. The figures in brackets are the number of replicates in each set of means.

The data in Table LIII are a reliable indication of total treatment influences on topsoil $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ content. Thus, whilst 4 cwt. per acre of ammonium sulphate applied twice,* once in each Long Rains during the experimental period, has approximately doubled the $\text{NO}_3\text{-N}$ level in the absence of a mulch, equivalent nitrogen applications as sodium nitrate have nearly trebled the control treatment level. It will be seen from the detailed figures given later that this difference between the fertilizers can largely be attributed to a late fertilizer application in the Long Rains 1956, i.e. at the beginning of the experiment, followed by an appreciable carry-over effect into dry weather. In the presence of a Napier grass mulch cover the $\text{NO}_3\text{-N}$ levels are altered with respect one to another. The unfertilized Napier grass mulched plots had a slightly higher $\text{NO}_3\text{-N}$ content than the unmulched control and this may be the effect of nitrogen derived from the breakdown of the mulch (*N.B.*—Napier grass was applied three times to mulched plots during the experiment so that a complete soil cover could be maintained) as well as the result of increased biological activity. The application of ammonium sulphate to the mulched soil raised the $\text{NO}_3\text{-N}$ level but not to anything like the degree that it did on the unmulched soil, when the figure for $\text{NO}_3\text{-N}$ derived from the Napier grass mulch alone is taken into consideration. Furthermore, the application of sodium nitrate fertilizer to the Napier grass mulched plots has not raised the $\text{NO}_3\text{-N}$ level as high as this fertilizer did when it was applied to the unmulched soil.

The $\text{NO}_3\text{-N}$ level under an inert stone mulch cover was lower even than that of the unmulched soil; when the two fertilizers were applied to the stone mulched plots the relative levels were similar to those for the Napier grass mulch treatments, and the absolute levels might also be considered similar, if due allowance is made for the $\text{NO}_3\text{-N}$ derived from the Napier grass.

From these figures it can be tentatively and very broadly concluded, therefore, that the presence of a mulch cover on this soil apparently reduces the quantity of natural $\text{NO}_3\text{-N}$ in the top foot, in the absence of nitrogenous fertilizers (the difference between the Napier grass and stone mulch treatments is assumed to be due principally to $\text{NO}_3\text{-N}$ derived directly and indirectly from leaching and decomposition of the organic mulch). With the application of nitrogenous fertilizers the soil $\text{NO}_3\text{-N}$ levels are raised in all treatments, but much less so, or for a reduced length of time, under the mulched than the unmulched treatments.

Except that the application of ammonium sulphate fertilizer raises $\text{NH}_3\text{-N}$ generally, but to a lesser degree when applied to either the Napier grass or a stone mulch treatment than to the control plots, the $\text{NH}_3\text{-N}$ figures show very little variation. There is no substantial evidence to suggest that general denitrification takes place with the accumulation of $\text{NH}_3\text{-N}$ in this soil, under a mulch cover.

Figure I shows the trends and differences in $\text{NO}_3\text{-N}$ levels for the various treatments together with the soil moisture variation and the rainfall between sampling periods. Where the graph lines are broken this represents long periods between spot samplings made during the dry seasons and the time interval on the graph is not to scale.

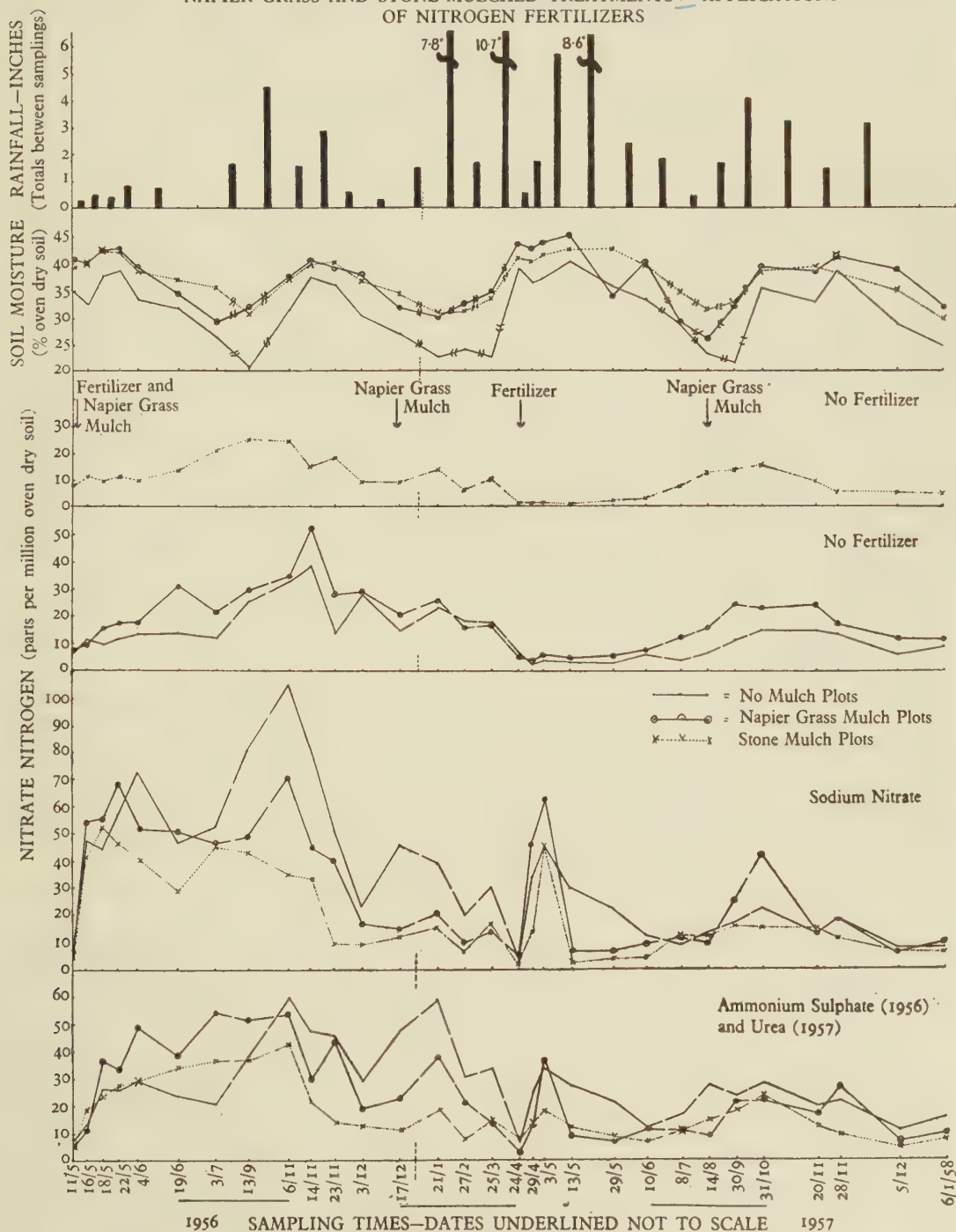
The generally lower soil moisture content of the unmulched treatments (represented by the control, unmulched, unfertilized plot values in Figure I) is very marked both in wet and dry seasons. The major differences in soil moisture content between the Napier grass and stone mulched plots can be related to the decomposition of the former. A low weighted mean value such as occurs at the time of sampling on August 14, 1957, is quickly raised by reapplication of more mulching material and subsequent rainfall.

Soil temperature differences were considerable between the mulched and unmulched plots throughout the experiment, but not between the Napier grass and stone mulch treatments. Prior to starting the experiment comparisons were made between unmulched, Napier grass and stone mulched fallow soils, with electrical thermistors placed 1 cm. below the soil surface. Whilst the temperatures of the unmulched and mulched soil at this depth could differ from 28°C . for the mulched plots to between $40\text{--}55^\circ\text{C}$. for the unmulched plots at the peak of the daily curve, the temperatures of the Napier grass and stone mulched soils were of the order of 27°C . and 28°C . respectively, a difference of only 1°C . Presumably in this experiment as the Napier grass mulch decomposed, such a difference was greater at certain times but a complete and effective cover of Napier grass was maintained as far as possible throughout the experiment.

Comparing the control, Napier grass and stone mulched plots it is apparent that natural $\text{NO}_3\text{-N}$ fluctuations were less under the inert stone mulch. Consistently more $\text{NO}_3\text{-N}$ is present in the

* In fact, this treatment was applied for the second time in the form of urea.

Figure 1. NITRATE NITROGEN, SOIL MOISTURE AND RAINFALL DATA FOR UNMULCHED, NAPIER GRASS AND STONE-MULCHED TREATMENTS APPLICATIONS OF NITROGEN FERTILIZERS



Napier grass mulched soil than in the unmulched or in the stone mulched soil. This is probably partly the influence of nitrogenous material derived from the organic mulch, and partly a greater active microbiological soil population, coupled with more advantageous soil moisture conditions during the dry months.

It will be observed that the general shape of all these graphs is very similar. It is in fact typical of the pattern of $\text{NO}_3\text{-N}$ trends in this soil, as has been determined in previous experimental studies. There is a steady build-up of $\text{NO}_3\text{-N}$ during the dry months (July to November in 1956, June to September in 1957) followed by a short, sharp rise with the early onset of the rains and a rapid falling off of $\text{NO}_3\text{-N}$ which may remain at a very low level for some time if consistent and heavy rain continues (refer period of Long Rains 1957, April-June).

Before describing briefly the graph for the fertilizer $\pm$ mulch treatments it is necessary to point out two major and fundamental differences between experimental conditions during 1956 and 1957. Firstly, 1956 was a relatively dry or rather "average" year compared with rainfall during 1957, which was higher than anything previously recorded. Secondly, the nitrogen fertilizers were all applied towards the end of the main rains period in 1956 but during the first half of the rains in 1957. The latter time is more nearly in line with current field practice but not entirely with the latest recommendations on this subject. It should also be mentioned that in 1957 urea was substituted for ammonium sulphate.

The principal difference in the graphs is that between 1956 and 1957. Application of nitrogen fertilizers during the second half of the Long Rains 1956 and when followed by only light rainfall has resulted in a substantial carryover of $\text{NO}_3\text{-N}$ through the dry months and into the Short Rains. $\text{NO}_3\text{-N}$ then fell markedly during the Short Rains, commenced to rise again as the rains stopped but was then probably leached through the topsoil profile by the heavy unseasonal rain during January, February and March. Very heavy rain coupled with an early application of fertilizer in the Long Rains 1957 quickly reduced soil $\text{NO}_3\text{-N}$ to a low level; it rose again during the drier months of July, August, September and October, but fell during the latter part of the Short Rains, in late November and December.

With a few exceptions the unmulched fertilized soil maintained the highest levels of $\text{NO}_3\text{-N}$ whilst the inert stone mulched soil had a consistently lower $\text{NO}_3\text{-N}$ level. The intermediate level of the Napier grass mulched plots might be attributed again to nitrogen derived from the mulch, etc. etc., as previously mentioned in this section.

Sodium nitrate raised the soil $\text{NO}_3\text{-N}$ level in the mulched and unmulched treatments very rapidly. Levels had risen very substantially in five days whereas the highest $\text{NO}_3\text{-N}$ levels in the ammonium-sulphate-treated plots (1956 Long Rains) occurred from 11-24 days after application, and in the urea-treated plots (1957 Long Rains) about nine days after application.

There was a very rapid loss of $\text{NO}_3\text{-N}$ from the Napier grass and stone mulched plots following both types of fertilizer application in the Long Rains 1957, compared with the much slower decline of the unmulched soil $\text{NO}_3\text{-N}$ levels. This is attributable largely to rainfall and leaching down from the top foot of the soil profile. The general impression is that :

- (a) The general shape of the $\text{NO}_3\text{-N}$ curves for the fertilizer-treated plots is broadly similar to the natural $\text{NO}_3\text{-N}$ trends;
- (b) For equivalent quantities of nitrogen applied in the nitrate or ammoniacal forms, more $\text{NO}_3\text{-N}$ is found in the topsoil of the sodium nitrate treated plots. This suggests some inefficiency through loss of nitrogen from the ammonium sulphate and urea fertilizers.
- (c) $\text{NO}_3\text{-N}$ derived from sodium nitrate was present at certain times in far higher concentrations than that derived from ammonium sulphate, but the persistence of higher soil $\text{NO}_3\text{-N}$ values accumulated during the dry months and carried into the Short Rains period was not so great. In other words, nitrification of fixed ammonia in the soil derived from the ammonium sulphate fertilizer continued after the rains fell or this fertilizer influenced conditions of the soil, or in the soil, directly or indirectly, in some way favourable to increased $\text{NO}_3\text{-N}$ formation.

The graphs for $\text{NH}_3\text{-N}$ are not given here, but the trends were simple and the shape as expected. There was very little, if any, difference between the unmulched and Napier grass or stone mulched treatments with or without the application of sodium nitrate. This fertilizer had no significant influence on the $\text{NH}_3\text{-N}$ level in the soil. As would be expected, ammonium sulphate and urea

fertilizers raised the levels considerably, and where the soil was mulched, this level fell rapidly during the wet weather.

The carryover of fertilizer nitrogen in the soil from the Long Rains to the Short Rains 1956 is illustrated in Table LIV, which summarizes the $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ data for sampling intervals before, during and after the Short Rains.

TABLE LIV
Summary of the changes of $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ with sampling times for residual treatments over the Short Rains 1956 period

Treatments Date: Rainfall between sampling times (inches)		Sampling Intervals—Days cumulative						
		13/9 0. —	6/11 54. 2.45"	14/11 62. 1.58"	23/11 71. 2.84"	3/12 81. 0.58"	17/12 95. 0.31"	21/1/57 130. 1.45"
Control (1)	a.	29.9	36.1	38.9	10.5	24.8	13.0	24.6
	b.	3.6	5.0	5.8	3.9	1.8	2.0	2.2
Ammonium Sulphate (S/A)	a.	46.2	64.3	43.4	37.0	26.0	42.2	60.0
	b.	25.6	17.4	12.4	9.2	3.1	2.7	2.2
Sodium Nitrate (N/S)	a.	103.1	116.6	82.6	42.0	21.9	41.3	37.3
	b.	6.3	5.8	5.1	4.3	3.9	2.0	2.6
Napier grass mulch (N.G.M.)	a.	30.7	37.1	37.6	23.7	25.7	18.9	26.3
	b.	4.2	5.5	5.8	4.2	2.0	2.1	2.4
Stone mulch (S.M.)	a.	25.2	24.6	11.7	7.3	10.0	9.2	14.9
	b.	3.3	5.8	5.8	3.1	2.3	2.3	2.0
S/A + N.G.M.	a.	57.7	52.7	27.0	41.0	16.7	19.8	35.6
	b.	3.7	5.7	5.5	3.8	2.9	1.9	2.3
N/S + N.G.M.	a.	51.5	81.5	36.1	30.6	15.3	13.3	19.0
	b.	4.0	6.0	4.5	4.5	4.3	2.1	2.0
S/A + S.M.	a.	39.4	38.9	22.2	10.9	13.1	10.6	18.0
	b.	4.5	5.6	5.5	3.5	4.9	1.8	2.2
N/S + S.M.	a.	44.3	26.9	22.8	7.3	9.2	12.0	15.6
	b.	4.7	5.7	4.4	2.8	2.2	2.7	2.0
L.S.D.s (Means of 6)	a.	20.5*	27.1**					
	b.	6.1*	8.1**					

Notes: 1. a = $\text{NO}_3\text{-N}$; b = $\text{NH}_3\text{-N}$ as parts per million over dry soil.

2. Short Rains period sampling from 6.11.56 to 17.12.56 inclusive.

The general trend is of a build-up of $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ between the first and second sampling periods when the weather was relatively dry. With the onset of the rains in early November, $\text{NO}_3\text{-N}$ tended to drop, particularly where levels were high when the second sampling was made. This was probably the result of leaching. In the control and Napier grass mulch treatments the $\text{NO}_3\text{-N}$ levels were maintained, probably through nitrification keeping pace with losses in the former and perhaps because of leaching from the decomposing Napier grass mulch residues on the soil surface in the latter treatment. $\text{NO}_3\text{-N}$ levels continued to drop then until the end of the rains (sixth sampling) but again built up during the relatively short period of dry weather which followed.

The greatest significant differences were found between the unmulched, the Napier grass and the stone mulched plots which received ammonium sulphate or sodium nitrate. The average soil moisture content was lower in the unmulched plots than in either type of mulched plots which in fact had very similar soil moisture values. The $\text{NO}_3\text{-N}$ levels were greatest in the unmulched plots which received either ammonium sulphate or sodium nitrate, when the values are compared with the mulched plots receiving the same type of fertilizer dressing. This was particularly the case for the stone mulch plots, e.g. ammonium sulphate or sodium nitrate treatments versus stone mulch plus ammonium sulphate or sodium nitrate. The Napier grass mulched plots which received these fertilizers were usually intermediate.

There seems to be no reason to suppose that leaching of $\text{NO}_3\text{-N}$ was greater under the stone mulch than under the Napier grass mulch and the obvious inference is that (a) both mulches have reduced the $\text{NO}_3\text{-N}$ levels in the soil and (b) that either sufficient $\text{NO}_3\text{-N}$ was derived directly from the Napier grass and/or greater microbiological activity took place in the soil beneath this mulch, to account for the higher $\text{NO}_3\text{-N}$ levels found compared then with the stone mulch treatment.

If these $\text{NO}_3\text{-N}$ results are compared with those found for the Long Rains 1956 sampling period (1) it is seen that the S/A + NGM treatment had a higher level of soil $\text{NO}_3\text{-N}$ than the control whereas the S/A + SM treatment $\text{NO}_3\text{-N}$ was similar to the control plot level for all sampling times. In the Short Rains results the S/A + NGM treatment $\text{NO}_3\text{-N}$ level was lower than the control treatment. A similar though more extreme difference is apparent between the sodium nitrate treatments.

$\text{NH}_3\text{-N}$ levels for all the treatments were high in the early stages of sampling and fell at the end of the rains (sixth sampling). The only statistically significant variations recorded were in soil samples from the unmulched ammonium-sulphate-treated plots. Substantially less $\text{NH}_3\text{-N}$ was present in all the mulched plots whether they received ammonium sulphate or not, and in all the other treatments. From a consideration of the ammonium-sulphate $\pm$ mulch-treated plots only, it is apparent that both mulch types have in some way reduced the levels of soil $\text{NH}_3\text{-N}$.

The fertilizer treatments were reapplied in the first half of the Long Rains 1957 when urea was substituted for ammonium sulphate. The $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ data for the Long Rains sampling intervals are summarized in Table LV.

TABLE LV
Summary of the changes of $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ with sampling times, following the direct application of fertilizers—Long Rains 1957 period

Treatments Date:		Sampling Intervals—Days cumulative						
		26/4 0.	29/4 4.	3/5 8.	13/5 18.	29/5 34.	10/6 46.	8/7 77.
Rainfall between sampling times (inches)		—	2.16"	.32"	5.94"	8.54"	2.37"	1.80"
Control (1)	a.	5.1	2.0	3.3	2.4	2.8	5.4	5.2
	b.	—	2.7	1.8	3.3	2.5	2.8	3.5
Urea (U)	a.	5.0	27.3	34.6	25.1	21.0	9.9	16.9
	b.	—	23.4	16.1	16.8	5.6	2.9	3.5
Sodium Nitrate (N/S)	a.	3.3	39.1	52.2	28.7	16.4	7.4	7.7
	b.	—	2.3	1.9	2.6	2.3	2.7	2.6
Napier grass mulch (N.G.M.)	a.	4.3	3.9	5.7	3.6	8.6	7.9	13.2
	b.	—	3.5	2.4	3.7	2.3	3.2	3.0
Stone mulch (S.M.)	a.	1.3	0.9	3.1	0.9	2.6	3.9	8.1
	b.	—	4.7	1.6	2.9	2.1	3.4	2.5
U + N.G.M.	a.	3.1	14.0	36.8	6.2	7.4	11.6	10.9
	b.	—	36.6	8.2	3.3	2.6	4.7	2.8
N/S + N.G.M.	a.	3.8	53.4	67.9	5.7	7.1	9.0	10.3
	b.	—	3.8	4.3	4.0	2.3	3.0	3.2
U + S.M.	a.	8.4	15.1	20.6	8.7	8.3	6.5	10.1
	b.	—	36.3	14.9	10.2	2.7	3.8	3.1
N/S + S.M.	a.	1.7	14.6	53.1	2.0	4.1	3.7	11.6
	b.	—	3.8	4.5	3.6	1.9	3.3	2.9
L.S.D.s (Means of 6)	a.	14.4*;	19.1**					
	b.	5.5*;	9.9**					

- Notes: 1. a = $\text{NO}_3\text{-N}$; b = $\text{NH}_3\text{-N}$ as parts per million over dry soil.
2. Long Rains period sampling from 24.4.57 to 10.6.57.
3. Nitrogen fertilizers were applied after the 0 day sampling (25.4.47).

Between 8-18 days after application of either the urea or sodium nitrate fertilizer to the mulched plots the $\text{NO}_3\text{-N}$ level has fallen significantly in the top foot of soil, almost to the original level prior to the application. In the unmulched soil plots this fall in fertilizer plus natural $\text{NO}_3\text{-N}$ did not occur until some time between the 34th and 46th day after application.

The generally low levels of $\text{NO}_3\text{-N}$ (and $\text{NH}_3\text{-N}$ in the case of urea-treated plots) found after fertilizer application in the top foot of soil suggest that the fertilizer itself and/or the $\text{NO}_3\text{-N}$ derived from the fertilizer was strongly leached from the soil by heavy rain. That leaching of $\text{NO}_3\text{-N}$ took place is supported by the inversion of $\text{NO}_3\text{-N}$ concentration in the top foot of the soil, which is shown in Table LVI.

TABLE LVI
Mean $\text{NO}_3\text{-N}$ values for the interaction of Urea $\pm$ mulch treatments with sample depth and sampling time. Long Rains 1957

Treatment and Sample depth Rainfall between sampling times (inches)	Sampling Intervals—Days cumulative						
	0	4	8	18	34	46	77
	—	2.16"	0.32"	5.94"	8.54"	2.37"	1.80"
Urea 0-3"	3.1	39.5	50.8	14.6	71.4	6.6	16.9
3-6"	2.6	26.3	26.6	27.8	5.6	10.4	17.9
6-12"	9.4	16.1	26.4	32.7	21.0	12.6	15.9
Urea + N.G.M. 0-3"	4.0	24.2	42.4	2.5	7.8	13.1	12.3
3-6"	2.9	9.8	33.2	4.6	8.9	12.2	9.8
6-12"	2.4	8.0	34.7	11.6	5.3	9.3	10.4
Urea + S.M. 0-3"	17.5	24.2	26.4	3.2	10.0	5.0	7.9
3-6"	2.1	13.4	24.9	8.4	7.9	6.9	9.9
6-12"	5.8	7.7	10.5	18.0	7.0	7.5	12.6
L.S.D.s (Means of 2)	25.1*; 33.2**						

Notes: Data are given as parts per million oven dry soil.

Samplings made over the Short Rains 1957 period showed no significant difference in $\text{NO}_3\text{-N}$ or $\text{NH}_3\text{-N}$ between treatments and there was no indication of any carryover at all in the top foot of the soil. As it was an exceptionally wet year and as the nitrogen fertilizers were applied early in the Long Rains, this was not unexpected.

In summarizing the condition of $\text{NO}_3\text{-N}$ present in the top foot of the soil during this experiment it is necessary to differentiate between the organic Napier grass and the inert stone mulch and to separate the comparison between unmulched and mulched soil in the presence or absence of added nitrogen fertilizer.

1. Plots which received no nitrogen fertilizers had higher soil $\text{NO}_3\text{-N}$ under a Napier grass mulch than when unmulched. Plots mulched with an inert stone mulch showed less $\text{NO}_3\text{-N}$ fluctuation than either unmulched or Napier grass mulched plots, but soil $\text{NO}_3\text{-N}$ levels were lower than the Napier grass mulched soil and more nearly agreed with the unmulched soil. This suggests a link between the function of a mulch and the observed incidence of nitrogen deficiency in mulch-treated crops compared with unmulched controls, *when moisture is a limiting factor to growth*.

2. Napier grass mulched soil treatments which received nitrogen fertilizers in this experiment had lower $\text{NO}_3\text{-N}$ levels compared with the unmulched plots except shortly after the application of the fertilizer. Stone mulch soil $\text{NO}_3\text{-N}$ was always lower than that found in the unmulched plots when both received nitrogen fertilizer. The lower $\text{NO}_3\text{-N}$ levels under these two types of mulch, which provide similar soil moisture and temperature conditions, might be attributed to :

- Lower soil temperatures compared with unmulched soils.
- Greater soil moisture infiltration and therefore greater leaching from the upper part of the soil profile.
- Wetter soil conditions, i.e. a higher overall mean soil moisture level, compared with the unmulched soil, and hence poorer aeration with, even, a deficiency of soil oxygen.

This could lead to lower nitrification rates and even denitrification following anaerobic activity. However, no evidence of denitrification in the form of $\text{NH}_3\text{-N}$ accumulation under either type of mulch was found in this experiment. Gaseous losses from denitrification processes would therefore seem to come directly from $\text{NO}_3\text{-N}$.

3. The lower $\text{NO}_3\text{-N}$ levels found under the inert stone mulch plus fertilizer compared with the Napier grass plus fertilizer would seem to be related (by elimination!) to the supply of organic matter and nitrogen together with increased (relative) microbiological activity under the Napier grass mulch.

After the last sampling in this experiment at the end of 1957, all the plots were examined to a depth of 10 ft. to try to detect any differential accumulation of $\text{NO}_3\text{-N}$ or $\text{NH}_3\text{-N}$ which could be related to leaching from a particular treatment. The results are summarized in Table LVII.

TABLE LVII
Mean $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ values found in a 10-ft. Kikuyu red loam coffee soil profile for the different treatments and at the several depths sampled

Depth of Sample *	$\text{NO}_3\text{-N}$	$\text{NH}_3\text{-N}$	Treatment	$\text{NO}_3\text{-N}$	$\text{NH}_3\text{-N}$
3"	9.3	3.5	Control	41.4	3.7
1'	9.8	3.9			
2'	34.1	3.6	Napier grass mulch (N.G.M.)	34.7	2.8
3'	65.3	3.2	Stone mulch (S.M.)	37.8	3.0
4'	72.6	3.8	Sodium nitrate (N/S)	48.7	2.8
5'	73.7	3.2	Ammonium sulphate		
6'	63.5	2.3	or Urea (U)	44.2	2.7
7'	52.3	2.7	U + N.G.M.	47.7	4.1
8'	34.2	2.7	N.S + N.G.M.	44.0	3.7
9'	25.9	2.7	U + S.M.	41.7	3.1
10'	20.4	3.7	N/S + S.M.	37.3	2.8
L.S.D.s (Means of 18)	11.8* 15.6**	1.0* —	L.S.D.s (Means of 22)	— —	0.9* —

Notes: 1. * = a 4" soil core was taken with the indicated depth in the centre, i.e. 2" of soil above and below the indicated depth was sampled.
2. $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ data quoted as ppm. oven dry soil.

It is significant that, in terms of the mean residual $\text{NO}_3\text{-N}$ in a 10' profile after treatments involving substantial nitrogen applications had been made for almost two years, none of the treatments differed appreciably one from another: nor was there any statistically significant interaction between the $\text{NO}_3\text{-N}$ or the $\text{NH}_3\text{-N}$ value for treatments versus depth of sample. The difference between mean treatment $\text{NH}_3\text{-N}$ values, although statistically significant, was very small.

Very substantial differences in $\text{NO}_3\text{-N}$ concentration were found with sample depth, with the highest concentrations present between 3' and 7'. This is in fair agreement with the result of a previous set of determinations (2). Less than 50% of the $\text{NO}_3\text{-N}$ occurred in the upper 4' of the soil profile (extreme feeding root range) and of that, less than 5% in the top 3" of the soil. Variations in $\text{NH}_3\text{-N}$ were small throughout the whole 10'.

However, grouping the unfertilized treatments versus the fertilized treatments, the mean values of 38.0 and 43.9 ppm. $\text{NO}_3\text{-N}$ respectively (L.S.D. 5% = 3.6) were just significant. The difference is, however, small and it must be concluded that a substantial quantity of nitrogen was leached through the full 10' of soil profile, whether the soil surface was mulched or not, during the heavy rains of 1957, or was lost as gases.

The two replications of this trial were situated within five yards of each other and prior to this experiment, commencing in 1956, had been kept fallow and weed-free for five years. One of the replicates had been mulched with Napier grass continuously and the other had remained bare for the full five years. During the course of the experiment reported here some interesting and statistically significant variations have become apparent between these two blocks which are attributed to the residual effect of the $\pm$ Napier grass mulching. These differences are summarized in Table LVIII.

TABLE LVIII
Mean soil moisture $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ values for the two absolute replicates
of Experiment No. I

Time	Number of Determinations	Replication I (Bare Fallow)			Replication VI (Mulched Fallow)		
		H_2O	$\text{NO}_3\text{-N}$	$\text{NH}_3\text{-N}$	H_2O	$\text{NO}_3\text{-N}$	$\text{NH}_3\text{-N}$
Long Rains 1956	162	35.9	24.8	9.8	41.0***	36.8***	7.2
Short Rains 1956	189	31.7	26.3	5.1	34.6*	38.4***	3.8
Long Rains 1957	162	36.5	13.7	6.9	41.4***	14.7	4.4
Short Rains 1957	162	33.7	11.2	3.6	36.7***	17.7***	4.1

Notes: 1. H_2O = soil moisture expressed as per cent oven dry soil.
2. $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ expressed as parts per million oven dry soil.
3. * = Level of significance (f test) compared with comparable figure under Replication I; * = 5%; ** = 1%; *** = 0.1%.

These mean figures are calculated from the detailed sampling data obtained during each of the four rain seasons. They are each means for the nine different treatments per replication, at three sampling depths, for the top foot of the soil profile. They show higher $\text{NO}_3\text{-N}$, lower $\text{NH}_3\text{-N}$ and higher soil moisture contents in replication VI, which was a weed-free Napier grass mulched fallow for five years prior to the time when experiment No. I was started in May, 1956, than in replication I which was unmulched.

Whilst these differences may be simple replication variations, it is considered not improbable that they are the result of the residual influence of the five-year Napier grass mulch. This treatment has apparently left the soil with a greater ability to retain soil moisture and a higher level of nitrification, as characterized by consistently higher $\text{NO}_3\text{-N}$ and lower $\text{NH}_3\text{-N}$ values in the soil.

The influence of nitrogen fertilizers and mulch on growth, leaf nitrogen content and yield. (Experiment No. II.)

This trial was continued during 1957 with one slight modification. Whereas the fertilizer dressings were applied in the Long Rains 1956, either (a) all in one application or (b) in four applications of one-quarter of the total amount at 10-day intervals, in 1957 the split dressings were in two and not four equal applications, the first during the early part of the rains and the second towards the latter half of the rains.

TABLE LIX
Mean leaf nitrogen figures for seven sets of samples collected during the Long Rains 1956.
(Nitrogen per cent dry matter)

Treatments	Unmulched	Mulched*	Means (of 8)
Control (1)	2.187	2.245	2.216
Ammonium sulphate (4)†	2.299	2.262	2.280
Ammonium sulphate (4 × 1)	2.190	2.237	2.213
Urea (4)	2.179	2.241	2.210
Urea (4 × 1)	2.194	2.249	2.222
Means (of 20)	2.209	2.247	

Notes: 1. *The mulch in this experiment was Napier grass.
2. Figures in the body of the table are means of 4 absolute replications.
3. L.S.D.s: 2 means of 4 = 0.074*
2 means of 8 = 0.052*
2 means of 20 = 0.033*
4. †(4) denotes 4 cwt. per acre of ammonium sulphate, or the equivalent quantity of nitrogen as urea, applied in a single dressing; (4 × 1) denotes the fertilizer treatments applied in four equal quantities at 10-day intervals throughout the rains.

The analysis of leaf samples for nitrogen content has been made on the youngest fully mature pairs of leaves on a primary. This sampling position was chosen for two reasons, namely (a) that whatever the month of sampling such material will almost certainly be available on a tree no matter how severe the crop strain might be, and (b) because it is one of the earliest vegetative parts of the tree to show visible nitrogen deficiency during active growth and would therefore be sensitive to the availability of nitrogen. In fact, very little variation in leaf nitrogen per cent has been found to date for samples taken from different treatments in the trial. This is well illustrated by the mean leaf nitrogen data for seven sets of samples collected at approximately 10-day intervals during the Long Rains 1956, which are shown in Table LIX. Not all the leaf samples collected for analysis during 1956-1957 from this trial have yet been analysed. A more intense search is now being undertaken, however, to determine whether the cherry or older, more mature leaf samples will provide a more sensitive index to the nitrogen status of the tree.

These results show that in this experiment during the Long Rains 1956: (1) the overall mean leaf nitrogen content was significantly greater in the absence of Napier grass mulch, for the single 4 cwt. per acre dressing of ammonium sulphate applied in the first part of the rains, than either the control or any other nitrogen fertilizer treatment; (2) that in the presence of a Napier grass mulch there was no significant difference in leaf nitrogen content between any of the treatments although, overall, leaf nitrogen in samples from mulched treatments were significantly greater than from unmulched treatments.

The overall differences between treatment means in Table LIX are small, but consideration should be taken of the increased growth made by the trees in some of the treatments, e.g. mulch, 4 cwt. ammonium sulphate and 4×1 cwt. ammonium sulphate treatment (3). The Napier grass mulch treatment produced a significant increase in primary elongation of + 35.8% over the control, unmulched treatment, much of it during the main growth period in the Long Rains 1956, and yet the overall mean leaf nitrogen level during the same period was higher than the control. This suggests a rather higher uptake of nitrogen from the soil.

TABLE LIX
Mean Yield data for 1957/58 and mean cumulative growth measurements for the period 2.1.57-1.1.58. (Means of 4)

Treatment		(1)	Napier Grass Mulch	Means (of 8)
Control (1)	a.	9.9	10.5	10.2
	b.	100	91.4	100
	c.	100	106.4	100
4 cwt. Ammonium Sulphate	a.	10.6	11.8	11.2
	b.	100.5	92.9	101.1
	c.	99.1	104.7	99.1
2 × 2 cwt. Ammonium Sulphate	a.	11.6	16.8	14.2
	b.	100	94.2	101.6
	c.	97.2	106.6	99.1
213 lb. Urea	a.	12.2	6.1	9.1
	b.	88.5	100	98.6
	c.	94.3	105.7	97.2
2 × 106 lb. Urea	a.	12.7	10.1	11.4
	b.	89.3	109.4	102.8
	c.	102.8	109.4	102.8
Means (of 20)	a.	11.4	11.1	
	b.	100	100.3	
	c.	100	107.6	

L.S.D.s: (a) Not significant; (b) Not significant; (c) Not significant.

Notes: 1. (a) = yields in cwt. clean coffee per acre.
 (b) = growth elongation of the primaries as per cent of control.
 (c) = number of nodes, i.e. leaf pairs produced, as per cent of the control.

Neither the yield nor the mean cumulative growth records differed significantly between treatments for 1957, which was an exceptionally heavy rainfall year. The mean yields for the nitrogen fertilizers $\pm$ the presence of mulch appear to support the splitting of the fertilizer into two applications during the Long Rains period, i.e. one-half in the first third and one-half in the last third of the period. This will usually mean an application in the first or second week of April and a second application in the first part of May.

Although treatment differences for the growth data were not significant statistically it would appear that, despite no difference in terms of primary elongation for $\pm$ mulch over all the nitrogen treatments, rather more nodes and hence leaf pairs were produced during the year in the mulched coffee. This point is perhaps emphasized by the very slight differences that were found for the different nitrogen treatments $\pm$ mulch.

The yield data for the 1956/57 and 1957/58 crops were analysed on a cumulative basis. This was not possible for the growth data (for full periods of one year) as during the first year (1956) records were not kept until the first half of April.

TABLE LXI
Cumulative Yield Data for 1956-1958 Crops (cwt. clean coffee per acre per annum)

	(1)	S/A	Split S/A	Urea	Split Urea	Mean
(1) Mulch	8.01	10.18	9.55	9.12	7.93	8.96
	6.56	9.06	11.98	5.71	10.17	8.69
Mean	7.28	9.62	10.75	7.41	9.05	
Grouped Mean*	7.28	10.18		8.23		

L.S.D.s 2 means of 32 (grouped means of S/A v. $\frac{1}{2}$ Urea) = 1.91*.

1 mean of 16 }
and 1 mean of 32 } (grouped means of (1) v. S/A or Urea) = 2.33*.

Notes: 1. S/A = ammonium sulphate.

2. Split refers to fertilizer applications split into four equal lots in the Long Rains 1956, and two equal lots in the Long Rains 1957.

3. Data in main body of the table are means of 4 absolute replications over 2 seasons (8).

The grouped data show that in the first two years of this experiment ammonium sulphate has been more effective for increasing yields than urea, at equal rates of nitrogen application. A consideration of the means in the main part of the table suggests that, in the presence of mulch, i.e. in this experiment the fertilizers were actually applied on top of the mulch, splitting either of the fertilizer types into four or two applications increases their efficiency. This is apparently not the case when the fertilizers are applied to bare soil around unmulched trees. Further yield results from this trial will help to clarify these points in the future.

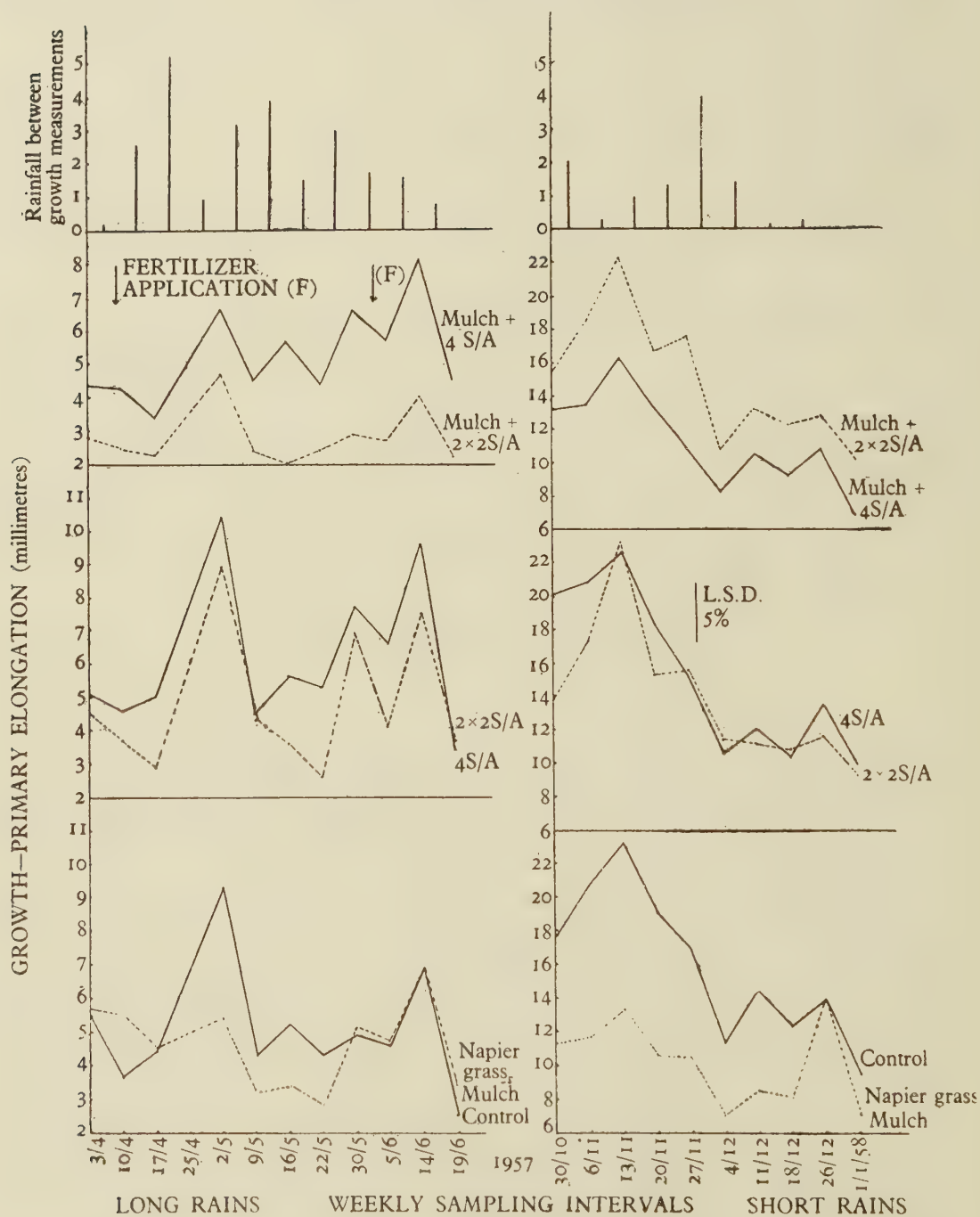
In Figure II, the growth measured as primary elongation at weekly intervals is shown for some of the treatments only, together with the total rainfall received between each measurement. These results were recorded by the Plant Pathologist/Physiologist and his staff.

Differences between treatments with sampling time were not significant for the Long Rains period. Rainfall was heavier than normal for the time of year and the coffee had been making a considerable amount of vegetative growth following unusually wet weather in the January-March period.* During the first half of the growth period recorded for the Long Rains the mulched trees do not appear to have made as much growth as the unmulched trees in the presence of adequate available soil moisture. Later, during this period, growth in these two treatments became very similar. In the absence of mulch there was a much smaller difference between ammonium sulphate applied in a single application as against two half applications than there was in presence of mulch; whilst the split ammonium sulphate application to mulched coffee altered the growth curve very little from that of the mulch alone treatment, the larger single application, whilst not altering the shape particularly, does appear to have increased growth overall. The first half of the split fertilizer

* Refer to Fig. III in this report.

Figure II.

GROWTH FOR CONTROL, MULCH AND AMMONIUM SULPHATE TREATMENTS



application (2 cwt./acre) was possibly too small to influence soil nitrogen appreciably for any great length of time (refer Fig. I, Expt. No. I), because of the heavy rainfall, the second half of the treatment was applied about one month too late to become available during a time of rapid growth. Dull, poor-growing weather conditions were prevalent during most of June. A residual of fertilizer nitrogen remained in the topsoil and probably resulted in the increased growth made during the Short Rains in the split nitrogen fertilizer plus mulch treatment.

The Short Rains growth was much faster in all the treatments than the Long Rains growth (the scale is reduced to one-half that of the Long Rains) because the primaries on which the growth was measured were those of a new set of young multiple-stem heads. The old cycle was completed with the harvesting of the crop.

Compared with the Long Rains 1956 growth patterns (3), splitting the nitrogen application in the Long Rains 1957 did not alter the shape of the growth curve in a period of unusually heavy and sustained rainfall. Much of the nitrogen fertilizer applied in the early part of the rains to mulched trees would have been lost by leaching beyond the effective root range. The mulch treated trees made significantly less growth than the unmulched trees during the Short Rains again; but, since the mean growth over the whole year made by the mulched trees (refer Table LX) was equal to, or even greater than, the unmulched (control) trees, substantially greater growth occurred in the mulched trees outside the usual major growth periods, i.e. during the first period of the Long and the Short Rains.

Laboratory incubation studies on the Kikuyu red loam coffee soil

An experiment was carried out to determine whether the mineralization of natural $\text{NH}_3\text{-N}$ and $\text{NO}_3\text{-N}$ was improved by the addition of small quantities of minerals to the soil prior to incubation.

A uniform topsoil sample (0-6") was collected from the field, air dried and broken down so that it passed through a 2 mm. round hole sieve. A total of eight plant nutrients were added, altogether in one treatment, and minus one of the nutrients in each of eight other treatments (Webb's subtractive technique). An untreated control was also included. Incubation was carried out at 30°C. and the soil was wet to field capacity. Duplicate flasks were withdrawn and analysed at 8, 16 and 32 days after incubation commenced. Statistical analysis of the $\text{NH}_3\text{-N}$ and $\text{NO}_3\text{-N}$ data showed highly significant differences in mineral nitrogen levels at the different times of sampling, but there was no interaction between sampling times and treatments. Overall mean treatment values are summarized in Table LXII. Soil $\text{NO}_3\text{-N}$ values at 0 day, i.e. commencement of the experiment, have been subtracted from the data.

TABLE LXII

Mean $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ for the mineral addition incubation experiment (ppm. oven dry soil)

<i>Treatments</i>	<i>$\text{NO}_3\text{-N}$</i>	<i>$\text{NH}_3\text{-N}$</i>
Complete	33.2	8.3*
— copper	35.5	7.4
— manganese	30.9	6.3
— molybdenum	33.1	7.3
— iron	32.7	7.2
— zinc	37.0	7.7*
— boron	31.1	7.0
— phosphorus	34.4	7.5
— calcium	34.0	6.7
Control, — all	29.1	6.7
L.S.D.s	Not significant	1.0*

Notes: 1. Data are means of 8.

The omission of any single nutrient from the soil has not influenced the mean $\text{NO}_3\text{-N}$ content of the soil significantly in this experiment, nor has the addition of all the nutrients together resulted in a $\text{NO}_3\text{-N}$ increase over the untreated soil. It is, nevertheless, interesting to observe that the lowest mean value found was for the control treatment which received no mineral addition at all.

Although differences were found between some of the $\text{NH}_3\text{-N}$ figures, no particular significance is attached to these results.

It would seem from the data that no gross mineral shortage in the soil (among the minerals added in this experiment) is inhibiting or reducing the production of natural soil $\text{NO}_3\text{-N}$. Further experimentation along these lines will be carried out.

An experiment was also carried out to determine the influence (if any) of couch rhizomes (*Digitaria scalarum*) on the mineralization of natural $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ in the Kikuyu red loam coffee soil.

The presence of couch grass in a coffee field always appears to have an adverse influence on the condition of the coffee which is out of all proportion to the degree of visible infestation. Weak growth of the coffee, yellowing of the leaves, poor cropping and eventual death are all symptoms associated with the presence of this weed, either as a complete ground cover or in isolated patches in a coffee field.

It has been postulated that the couch rhizome and root excretes or exudes some substance which is particularly harmful to the coffee, either directly or indirectly. Since many of the visible symptoms on couch infested coffee resemble closely severe and prolonged nitrogen deficiency and since the volume of visible couch grass does not suggest the total uptake of available soil nitrogen, it has been suggested that the exudate from the rhizomes and/or roots may in some way suppress nitrogen mineralization in the soil.

TABLE LXIII
Mean $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ data for the couch rhizome incubation experiment
(ppm. oven dry soil)

Treatments		Time Interval (days)				Means
		4	8	16	32	
Control (1)	a.	45.3 (2)	78.9	86.4	111.6	80.6 (8)
	b.	9.8	0.7	0.7	1.8	3.3
<i>Paspalum</i> root (d&g)*	a.	1.3	0.0	1.0	0.4	0.7
	b.	0.8	0.7	0.4	2.9	1.2
Couch Rhizome (d&g)*	a.	3.9	1.9	2.2	1.0	2.3
	b.	4.1	4.0	2.9	3.6	3.7
Couch Rhizome (d&ge)*	a.	11.3	43.6	82.3	132.1	67.4
	b.	16.4	17.5	2.8	1.9	9.7
Couch Rhizome (Fe)*	a.	41.1	88.8	123.0	155.0	101.9
	b.	37.2	22.4	1.1	2.4	15.8
Means	a.	20.6 (10)	42.7	59.0	80.0	
	b.	—	—	—	—	
L.S.D.s:						
Means of 2		(a) = 7.8*	14.6***	(b) = 2.0*	3.8***	
Means of 8		(a) = 3.9*	7.3***	(b) = 1.0*	1.9***	
Means of 10		(a) = 3.6*	6.6***	(b) = —	—	

- Notes: 1. * = d&g = dried and ground to pass a 20-mesh (U.S.A.) sieve.
d&ge = water extract of dried ground material.
Fe = water extract of fresh material.
2. Figures in brackets are the number of replicates in each mean.
3. $\text{NO}_3\text{-N}$ content of soil at 0 day = 17.8 ppm.
 $\text{NH}_3\text{-N}$ content of soil at 0 day = 16.9 ppm.
4. a = $\text{NO}_3\text{-N}$; b = $\text{NH}_3\text{-N}$.

Kikuyu red loam topsoil (0-6") was incubated in the laboratory with (a) a water extract from both fresh and dried couch rhizomes, and (b) with dried, ground couch rhizome material. Also included in the treatments were untreated soil and soil which received an equal weight of the dried roots of *Paspalum notatum*. This is a grass frequently used to stabilize the faces of bench terraces and has been observed as one of the least harmful (visibly) to coffee growth and crop production.

60 gm. portions of air dry soil were incubated at 30°C. in duplicate, for 4-, 8-, 16- and 32-day periods. 5 gms. of dried couch rhizome and *Paspalum* root were added to the soil in the respective treatments. Where extracts of couch rhizome were added to the soil these replaced the initial water addition when wetting the air dry soil for incubation. The soil moisture content was maintained at about the field capacity level for the period of incubation.

Both the *Paspalum* root and the couch rhizome (dried and ground) have completely prohibited the production of significant amounts of $\text{NO}_3\text{-N}$ over the incubation period because the addition of organic matter was too great, resulting in a very wide carbon : nitrogen ratio. The slightly higher $\text{NH}_3\text{-N}$ figures throughout for the couch rhizomes probably reflects the higher total nitrogen content, i.e. 0.614% dry matter for the couch rhizome as against 0.549% dry matter in the *Paspalum* roots. It is interesting to note, however, the depression of $\text{NO}_3\text{-N}$ production until the eighth day of sampling, which resulted from the addition of the dried and ground couch rhizome extract. This trend was not supported by the results of the fresh couch rhizome extract treatment which closely parallels the control treatment for the first eight days. A consideration of both the $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ figures for the two couch rhizome extract treatments shows that a substantial amount of readily mineralized soluble nitrogen material was probably added to the soil in the extracts: this is more pronounced for the fresh than for the dry couch rhizome extract.

The results of this experiment suggest that there is no particular substance (or substances) contained in the couch grass rhizome which suppresses $\text{NO}_3\text{-N}$ formation in a particularly marked manner, but further modified experiments are proposed to investigate this point more closely.

MAGNESIUM NUTRITION OF COFFEE

The small magnesium survey trial which began in 1954 was continued (4). Over the years 1954 to 1957 (inclusive) magnesium fertilizer in the form of Epsom salts has been applied annually at a rate of 40 lb. per acre. No leaf analysis figures have, up to 1957, shown any significant change with this treatment, probably because the dressing is too light and also, as stated in the previous report, because the leaf samples collected for analysis were not taken from the most sensitive part of the branch. Commencing with the 1958 treatments, these factors have been corrected (a) by applying Kieserite at a rate of 2 cwt. per acre and (b) by sampling, in addition to the youngest pair of mature leaves, a further sample of more mature leaves. This modification of the treatment and sampling technique coincides with the beginning of a new multiple-stem cycle in this coffee and it will be interesting to observe the results. In 1957 also the trees received an alternate inter-row Napier grass mulch for the first time. This treatment is to be continued and it will undoubtedly emphasize the value of the magnesium fertilizer application in future years, based on previous findings (5).

TABLE LXIV
Mean Yield Data, 1954-1957 (cwt. c.c. per acre)

Treatment	Year				Means
	1954	1955	1956	1957	
+ Mg.	6.2 (5)	1.5	6.5	2.0	4.1 (20)
- Mg.	5.0	3.1	4.6	3.9	4.2

The only statistically significant differences in this trial were between seasonal yields. During three years without mulch and one year with, there has been no overall yield increase from the application of 40 lb. of Epsom salts per acre per annum. Following the consistent annual Napier grass mulching (from 1957), higher magnesium fertilizer application (from 1958) and the start of a new pruning cycle (from 1958), it will be interesting to see to what extent, during the next four years, the magnesium fertilizer will counteract the effect of the heavy additions of potassium to the soil from the Napier grass mulch.

TABLE LXV
Leaf Calcium, Magnesium and Potassium Analyses†

Element† and Treatment	1	2	3	4	5	6	7	8	9	10	11	12	Means (of 120)
Calcium L.S.D.s (10)	0.68	0.79 0.06*	0.61 0.08**	0.73	0.66	0.68	0.83	0.66	0.70	0.69	0.64	0.78	0.70
Magnesium L.S.D.s (10)	0.31	0.33 0.04*	0.31 0.05**	0.39	0.29	0.32	0.31	0.34	0.37	0.32	0.28	0.35	0.33
Potassium L.S.D.s (10)	2.86	2.87 0.15*	2.93 0.20**	2.89	2.63	2.44	2.66	2.50	2.29	2.40	2.35	2.49	2.61
K - Mg. K + Mg. L.S.D.s (5)	2.89 2.83	2.85 2.89 0.21*	2.86 3.00 0.28**	2.91 2.87	2.63 2.62	2.43 2.45	2.72 2.59	2.65 2.34**	2.57 2.02**	2.43 2.38	2.41 2.29	2.49 2.49	2.56 2.65

- Notes: 1. † = Figures are per cent leaf dry matter.
2. 1 - 12 Sampling times, represents January-December, 1957, monthly samples collected at the end of each month.
3. K ± Mg. = Leaf potassium figure in the presence and absence of magnesium fertilizer applied to the soil.

As in the previous year (4), low leaf analysis values were recorded for May, the last part of the Long Rains period. The overall leaf potassium mean value is very similar for both years, but the calcium and magnesium figures were appreciably lower in 1957 than in 1956; the level of cropping in 1957 was significantly lower than in 1956, it was much wetter in 1957 and the trees were at the end of a pruning cycle. Growth was made over longer periods because of unseasonal rainfall and all these factors combined together may account for the lower calcium and magnesium leaf values found. Potassium being amply available in this soil, and particularly so in 1957 when the trees were mulched with Napier grass for the first time, no strain was apparently imposed on the uptake of this nutrient by the coffee.

The most interesting feature of this data is the significant treatment versus sampling time interaction for potassium. Following the application of Napier grass mulch and the addition of extra potassium to the soil (6) and hence available to the coffee tree, the magnesium fertilizer has apparently reduced the uptake of potassium in the months of August and September.

It is probable that the reason for this interaction lies with the balance of potassium and magnesium availability in the soil.

CHELATED PLANT NUTRIENT APPLICATIONS TO COFFEE

1. Iron Chelate Trial

A trial was laid down in the Long Rains 1957 to examine the effect of iron chelate applications to mature coffee. Because of the limited supply of the chelate material, single-tree plots were necessary and the final layout comprised six replications of three treatments. The treatments were control, $\frac{1}{4}$ and $\frac{1}{2}$ lb. per tree of the chelate (Na Fe E.E.D.T.A., 57% chelate compound or 9% Fe metallic), applied dissolved in a suitable volume of water, during the first part of the Long Rains. An equal volume of water only was applied to the control (untreated) trees.

Leaf samples were collected for analysis just prior to application of the treatments and on four subsequent occasions during the Long Rains, at regular intervals. The sample comprised the terminal pair of mature leaves. The coffee is mature (about 35-year-old French Mission type) and is pruned on the multiple-stem system.

The mean yield results and leaf analysis data are summarized in Table LXVI.

TABLE LXVI
Mean yield and iron content of the leaf dry matter for treatment and sampling times

Treatment	Yield		Mean leaf Fe content over 5 samplings (p.p.m.)		
(1)	14.9 (6)		56 (30)		
$\frac{1}{4}$ lb. NaFe E.E.D.T.A.	15.9		57		
$\frac{1}{2}$ lb. NaFe E.E.D.T.A.	19.5		61		
Sampling Times	1	2	3	4	5
Date	11.4.57	25.4.57	9.5.57	23.5.57	7.6.57
Means (of 18)	39	60	66	61	65
L.S.D.s	12.0*;		21***		

Neither the mean yield nor the leaf iron figures for the different treatments showed statistically significant treatment differences although the higher rate of chelate application has apparently varied the yield quite appreciably. Whilst the mean leaf iron figures did not differ greatly between the treatments, there was a substantial overall mean variation in leaf iron content with sampling time. Apparently, early in the rains, the leaf iron content was low and during the following 14 days it increased by half as much again irrespective of the chelate application. This trial is being continued.

2. Mixed Chelate and Fritted Trace Element (Glass) Trial

This trial was laid down in the Long Rains 1956 when SL.9 seedlings of a uniform age and size were planted out in the field, 9' $\times$ 9' square. The trial was put down to determine the influence of plant nutrients, supplied individually as chelates and in the form of an industrial by-product (iron Lignin Sulphonate) or several of them together in a glass frit mixture (F.T.E.) supplying iron,

manganese, zinc, boron, copper and molybdenum, on the early establishment growth and yield capacity of the trees.

There are nine treatments, including the control, and each treatment is split for ± 1 ndebe of cattle manure. Thus, each plot treatment comprises two seedlings and there are seven replications in a randomized block layout. The seedlings are pruned on a two-headed multiple-stem system.

The cattle manure, chelate, F.T.E. and iron lignin sulphionate treatments were applied in the hole at the time of planting out the seedlings (May, 1956). There was a single exception to this, i.e. treatment No. 9, the iron + manganese chelates at a double rate of application, which were applied in September, 1956. In November, 1957, all the treatments except cattle manure were reapplied and the magnesium chelate treatment was amended to an equal application of Epsom salts (hydrated magnesium sulphate) at a similar rate of magnesium per tree.

No crop yields have been recorded to date but in June, 1957, and in May, 1958, measurements were made of stem diameter at a point 6" above the ground level and below the point of capping in the nursery. Initially, in 1956, growth measurements were made (a) of the single-stem diameter 6" above the ground level, (b) of each of the two multiple-stem diameters 6" above the point of capping, and (c) of the overall height of the tree. Less variability was found in the data obtained in (a) and this was the measurement repeated in 1958. The stem diameter figures recorded in June, 1957, showed no statistically significant difference due to treatments. The figures recorded in May, 1958, have been calculated directly together with the difference between the two sets of data, equal to the growth increment from June, 1957, to May, 1958, and this data is summarized in Table LXVII.

TABLE LXVII
Stem diameter and growth increment measured as stem diameter for the period June, 1957, to May, 1958, in centimetres

<i>Treatment</i>	<i>With C.M.</i>		<i>Without C.M.</i>		<i>Mean</i>	
	<i>1</i>	<i>2</i>	<i>1</i>	<i>2</i>	<i>1</i>	<i>2</i>
Control (1)	3.42	+1.54 (7)	3.65	+1.78 (7)	3.54	+1.66 (14)
92 gms. F.T.E.	3.88	+1.76	3.16	+1.25	3.52	+1.51
25 gms. Fe Lig. Sulphonate	3.31	+1.49	3.47	+1.62	3.39	+1.56
20 gms. Copper Chelate	3.82	+1.63	3.58	+1.76	3.70	+1.70
20 gms. Zinc Chelate	3.47	+1.59	3.52	+1.71	3.50	+1.65
20 gms. Manganese Chelate	3.26	+1.51	3.28	+1.39	3.27	+1.46
20 gms. Iron Chelate	3.07	+1.49	3.19	+1.52	3.13	+1.50
30 gms. Magnesium Chelate	3.33	+1.67	3.52	+1.74	3.43	+1.64
40 + 40 gms. Manganese and Iron Chelates	3.72	+1.35	3.54	+1.79	3.63	+1.58
Means	3.48	+1.56 (63)	3.44	+1.58 (63)	3.46	+1.57(126)

L.S.D.s *Stem diameter*, Treatment $\times \pm$ Cattle Manure interaction (Means of 7)
= 0.42*; 0.56**.

Stem diameter increment, Treatments (means of 14) = 0.21*.

Treatment $\times \pm$ Cattle Manure interaction (Mean of 7) = 0.34*.

- Notes: 1. The figures under columns marked 1 are stem diameter, and under 2 are stem diameter increment, both in centimetres.
2. The bracketed figures are the number of replicates in the means.

One ndebe of cattle manure in the planting hole has not influenced significantly either the mean stem diameter or the growth increase of the stem between June, 1957, and May, 1958.

None of the treatments has influenced the stem diameter significantly when the means are calculated for $\pm$ cattle manure application. The copper chelate treatment is apparently the most and the manganese chelate treatment the least beneficial of all the treatments. This trend is also

shown in the overall stem diameter increment means for the one-year period, i.e. the second year in the field, and in fact the mean difference between these two treatments is statistically significant.

The most interesting effects in terms of stem diameter appear to be the interaction of some of the treatments with cattle manure. Thus, the fritted trace element treatment, in the presence of cattle manure, has substantially and significantly increased the mean stem diameter in relation to the same treatment in the absence of cattle manure. Whilst no other treatment difference (in terms of the stem diameter) is statistically significant in respect of the control value in the presence of cattle manure, there are other significant mean treatment differences which it is difficult to explain. The manganese chelate treatment has, if anything, depressed the mean stem diameter and this effect reaches statistical significance compared with the control, in the absence of cattle manure.

It will be interesting to see whether, in the future, crop yields are related to the growth differences attributable to the different treatments and particularly whether the application of cattle manure in the planting holes will result in yield increases.

A COMPARISON OF THREE TYPES OF PHOSPHORUS FERTILIZER FOR CROP PRODUCTION ON THE KIKUYU RED LOAM SOIL

The three simple trials in which three types of phosphorus fertilizer were compared in the presence and absence of a nitrogen fertilizer were terminated early in 1958 with the Short Rains 1957 crop harvest.

TABLE LXVIII
Yields of Napier grass mulch for six seasons (mean of 3 replications)

<i>Nitrogen Treatments</i>	<i>Phosphorus Treatments (Tons dry matter per acre)</i>				<i>Means</i>
— N	(1)	Ps.	Phr.	Pbs.	
LR..55	4.57	4.70	4.55	4.69	4.63 (12)
S.R.57	1.80	2.04	1.72	21.5	1.93
L.R.56	3.07	3.90	3.73	4.63	3.83
S.R.56	2.80	3.33	2.72	3.26	3.03
L.R.57	4.01	5.75	5.37	6.26	5.35
S.R.57	3.11	5.96	4.55	4.20	4.45
Means (18)	3.23	4.28	3.77	4.20	3.87 (72)
+ N					
L.R.55	4.78	4.75	4.71	4.83	4.77
S.R.55	1.96	2.21	1.94	2.06	2.04
L.R.56	3.82	4.58	3.89	3.65	3.98
S.R.56	2.82	3.66	2.89	2.75	3.03
L.R.57	5.17	7.14	5.20	5.85	5.84
S.R.57	4.57	6.33	4.63	5.20	5.18
Means (18)	3.88	4.78	3.88	4.06	4.15 (72)
Overall Means (6)					
L.R.55	4.67	4.72	4.63	4.76	4.69 (24)
S.R.55	1.88	2.12	1.83	2.10	1.98
L.R.56	3.44	4.24	3.81	4.14	3.91
S.R.56	2.81	3.49	2.80	3.00	3.02
L.R.57	4.59	6.44	5.28	6.05	5.59
S.R.57	3.84	6.14	4.59	4.70	4.82
Means (36)	3.55	4.53	3.83	4.24	

L.S.D.s: Means of 3. (Interactions Seasons $\times$ Treatments) = 1.05*, Tons D.M./acre.

Means of 18. (Overall Individual Treatment) = 0.86*; 1.19**, Tons D.M./acre.

Means of 24. (Seasons) = 0.37*; 0.49**, Tons D.M./acre.

Means of 36. (Overall Phosphorus Fertilizer Treatments) = 0.61*; 0.84**, Tons D.M./acre.

Notes: 1. $\pm$ N = $\pm$ Ammonium sulphate (1 cwt./acre) applied in each season.

Ps = 42 lb. water soluble P_2O_5 ; 100 lb./acre double superphosphate each Long Rains.

Phr. = 42 lb. Citric soluble P_2O_5 ; 145 lb./acre hyperphosphate reno each Long Rains.

Pbs. = 42 lb. Citric soluble P_2O_5 ; 292 lb./acre basic slag each Long Rains.

2. L.R. = Long Rains and S.R. = Short Rains seasons.

3. Figures in brackets after means indicate number of figures in means.

The three types of phosphorus fertilizer being compared were double superphosphate (42% water soluble P_2O_5), basic slag (18% P_2O_5 , 80% citric soluble) and hyperphosphate reno (a French North African rock phosphate containing 27.30% P_2O_5 , 98% citric soluble).

1. *Perennial Napier grass (Pennisetum purpureum) for coffee mulching*

The previous history of the experimental site together with details of the statistical layout were recorded in the 1956/57 Annual Report from this Station (7).

A summary of the seasonal yield data is given in Table LXVIII.

Nitrogen fertilizer has had no overall significant effect in this experiment, either direct or in combination with any of the phosphorus fertilizers. There was, however, a significant interaction in the Long Rains 1957 season when yields were particularly high, between ammonium sulphate and double superphosphate, and indications of such an interaction in other seasons as well. The Long Rains 1957 effect is attributable to the abnormally wet season.

At the rates of phosphorus fertilizer application in this experiment, there is little to choose between double superphosphate and basic slag in terms of yield, although double superphosphate is more economic at present prices. Hyperphosphate reno is markedly less effective in this soil than either of the other two phosphorus fertilizers.

A close inspection of the treatment $\times$ season mean data shows not only the advantageous yield trends from the combination of ammonium sulphate plus double superphosphate but also an antagonism between ammonium sulphate and basic slag in some seasons, e.g. Long Rains 1956 and 1957.

2. *Silage maize; white maize (Long Rains) and White Haricot beans (Short Rains)*

(a) Maize Silage :

The final yield data for the three Long Rains crops (1955, 1956 and 1957) are summarized in Table LXIX. Details of the experimental layout are given in the 1956/57 Annual Report from this Station (8).

TABLE LXIX
Yields of Silage Maize (means of 3 replications)

Nitrogen Treatments	Phosphorus Treatments (Tons dry matter per acre)				Means
	(I)	Ps.	Phr.	Pbs.	
— N					
1955	1.28	2.01	1.21	1.53	1.51 (12)
1956	1.96	3.13	2.69	3.47	2.81
1957	0.62	0.56	0.71	0.68	0.64
Mean (9)	1.29	1.90	1.54	1.89	1.66 (36)
+ N					
1955	1.17	1.71	1.38	1.61	1.47
1956	1.82	3.12	2.70	3.23	2.72
1957	0.83	1.08	1.06	1.10	1.02
Mean (9)	1.27	1.97	1.71	1.98	1.73 (36)
Overall Means (6)					
1955	1.22	1.86	1.29	1.57	1.48 (24)
1956	1.89	3.12	2.69	3.35	2.76
1957	0.72	0.82	0.88	0.89	0.83
Means (18)	1.28	1.93	1.62	1.93	1.69 (72)

L.S.D.s: Means of 3 (Interaction Seasons $\times$ Treatment) = 0.35*; 0.67***. Tons D.M./acre.

Means of 9 (Overall treatments) = 0.32*; 0.45**. Tons D.M./acre.

Means of 18 (Overall phosphorus fertilizer treatments) = 0.23*; 0.31**. Tons D.M./acre.

Means of 24 (Seasons) = 0.12*; 0.24***. Tons D.M./acre.

Means of 36 (Overall nitrogen fertilizer treatments) = 0.15*. Tons D.M./acre.

Notes: Fertilizer treatment nomenclature as for previous Table LXVIII.

Considering first the mean treatment yields over the three seasons, it is surprising that there is no significant yield response to ammonium sulphate with this crop. Again, as in the Napier grass trial, double superphosphate and basic slag have given similar and significant responses; a significant yield response is also recorded for hyperphosphate reno in comparison with the control treatment, but the yield increase over the control with this fertilizer is significantly less than either double superphosphate or basic slag.

Again, there was a significant response to ammonium sulphate with, in this trial, each of the phosphorus fertilizers over the phosphorus fertilizer applied alone in the 1957 Long Rains season only. As in the Napier grass trial, this is attributed to the effect of heavy rainfall which, compared with the 1956 Long Rains season, depressed yields significantly in this trial.

The economic conclusion from this trial is that, at the rates used, double superphosphate is to be preferred to basic slag.

White Haricot Beans

This legume crop was grown in each of the three Short Rains seasons on the residual fertilizer treatments from the maize silage plots.

TABLE LXX
Yields of White Haricot Beans (means of 3 replications)

<i>Nitrogen Treatments</i>	<i>Phosphorus Treatments (Pounds threshed beans per acre)</i>				<i>Means</i>
— N	(I)	Ps.	Phr.	Pbs.	
1955	152.4	179.6	185.1	210.5	181.9 (12)
1956	361.1	504.4	444.5	518.9	457.2
1957	342.9	440.9	420.9	566.1	442.7
Means (9)	285.4	374.9	350.2	431.8	360.6 (36)
+ N					
1955	165.1	197.8	161.5	208.7	183.3
1956	420.9	489.9	424.6	444.5	444.9
1957	312.1	488.1	408.2	442.7	412.8
Means (9)	299.4	391.9	331.4	365.3	347.0 (36)
Overall Means (6)					
1955	158.7	188.7	173.3	209.6	182.6 (24)
1956	391.0	497.1	434.5	481.7	451.0
1957	327.5	464.5	414.5	504.4	427.7
Means (18)	292.4	383.4	340.8	398.5	

L.S.D.s: Means of 3 (Interactions Seasons $\times$ Treatments) = 50.8* lb./acre.
Means of 9 (Overall Treatments) = 61.7*; 87.1** lb./acre.
Means of 18 (Overall phosphorus fertilizer treatments) = 43.5*; 59.9** lb./acre.
Means of 24 (Seasons) = 19.2*; 34.3*** lb./acre.
Means of 36 (Overall nitrogen fertilizer treatments) = 31.5* lb./acre.

Notes: Fertilizer treatment nomenclature as for Table LXVIII.

Ammonium sulphate has had no direct and significant residual effect on yields in this trial. When applied with basic slag to the Long Rains maize silage crop, the residual effect of this combination has resulted in significantly lower yields than those obtained to a residual basic slag treatment alone. In the absence of ammonium sulphate the yield increase obtained with residual basic slag seems to be greater than that obtained for the double superphosphate treatment (just not significant).

All the residual phosphorus fertilizer treatments increased the yields of beans significantly, judged on the overall mean yields, and there was a strong indication that at these application rates both double superphosphate and basic slag residuals gave greater yield increases than did hyperphosphate reno.

Thus, whilst yields of silage maize were not significantly different in respect of the double superphosphate and basic slag applications, there is some evidence in the residual yield response of beans to these fertilizers which suggests that basic slag is the better fertilizer under local rainfall conditions when ammonium sulphate fertilizer is not applied to the Long Rains crop.

3. *Ley grasses*

This experimental layout was different from the previous trials in that (a) only the three phosphorus fertilizer treatments were applied: nitrogen was applied as a blanket dressing in the 1956 and 1957 seasons only, and (b) the three replicates comprised plots of three different grass species, established in the experimental grass plot area on this Station. It was expected that responses to phosphorus fertilizer would be substantial and that the results from this extremely simple layout would be capable of statistical evaluation. As, in fact, no treatment produced a significant yield response for any one of the six seasons, the overall mean yield results only are summarized in Table LXXI.

TABLE LXXI

Treatment	Mean Yield for 6 seasons (1955-1957) in tons Green Matter per acre per season		
	Varieties		
(1)	5.1 (18)	<i>Bothriochloa insculpta</i>	4.1 (24)
Ps.	4.8	<i>Setaria</i> sp. ex Nandi	6.1
Phr.	5.8	<i>Panicum maximum</i> var. <i>trichoglume</i>	5.0
Pbs.	4.7		
L.S.D.s	Not sig.	L.S.D.s	1.2*; 1.8**

Whilst no conclusions can be drawn from the mean treatment yield figures, in fact the mean yield for all these varieties at every one of the six cutting times was greater for the hyperphosphate reno treatment than for either double superphosphate or basic slag. This possible effect is a complete reversal of the previous results found in comparing these three fertilizer types with other crops.

Of the three varieties, Nandi *Setaria* grass has outyielded *Bothriochloa insculpta* very significantly, and *Panicum maximum* var. *trichoglume* appears to be intermediate in its yielding capacity when the grasses are cut once after each rains.

CULTIVATION AND CROPPING OF VLEI SOILS

The experiment with Camber Bed cultivation on a vlei soil at the Coffee Research Station was continued during 1957. The primary object of this experiment was to examine the potential of vlei areas when cultivated into Camber Beds, for the production of coffee mulching material.

It was apparent after cutting the Short Rains 1957 Napier grass crop that regeneration of the Camber Bed soil structure was desirable at the earliest opportunity as yields were beginning to decline. Thus, to date, four years of cropping have been carried out without any heavy cultivation being undertaken since the preparation of the cultivation scheme (9).

A full and detailed report of this trial has been prepared and submitted for publication elsewhere. In Table LXXII below, the Napier grass yields and mean treatment effects are summarized for the three years during which Napier grass has been grown.

TABLE LXXII
Napier grass yields* and treatment effects† on Camber Beds
(Tons per acre)

Treatment	Yield		Treatment Effects	
	Dry Matter	Green Matter	Dry Matter	Green Matter
(1)	1.45	6.44	—	—
N	1.67	7.42	+0.57**	+2.53
P	1.94	8.62	+0.85***	+3.77
C	2.50	11.11	+0.95***	+4.22
NP	3.16	14.04	+0.31	+1.37
NC	2.79	12.40	—	—
PC	3.09	13.73	—	—
NPC	3.63	16.13	—	—
L.S.D.s‡	0.63*; 0.88**; 1.22**;		0.32*; 0.44**; 0.61***	

- Notes: 1. * = means of 18, i.e. average yield per season for 6 seasons.
 † = difference between means of 72.
 ‡ = L.S.D.s refer to dry matter figures only.
 2. N = Ammonium sulphate fertilizer, P = double superphosphate (42-45% P_2O_5), C = cattle manure treatment.

Ammonium sulphate was applied during the Long and the Short Rains in 1955, 1956 and 1957 at a rate of 1 cwt. per acre; double superphosphate was applied at a rate of 1 cwt. per acre in the Long Rains of 1955, 1956 and 1957. Cattle manure was applied in alternate years, i.e. Long Rains 1955 and 1957, at a rate of 10 tons per acre.

The results of this experiment to date were summarized in a detailed report to be published elsewhere, in the following way :—

1. Groundwater (vlei) soils are capable of producing Napier grass for mulching coffee . . . when cultivated on the Camber Bed system.
2. For the establishment of Napier grass plantings on these soils it has been shown that 1 cwt. per acre of double superphosphate (42-45% P_2O_5) placed in the planting furrow is very beneficial. Alternatively, 10 tons per acre of cattle manure broadcast over the beds before planting has given almost equally good results. When establishing this crop on these soils it is recommended that one or the other of these treatments should be applied; if both these treatments are applied at this stage the post-establishment crop yield will be greater than when either one is applied alone.
3. Yields of established Napier grass have been substantially increased by application of nitrogen and phosphorus fertilizers and by cattle manure. The effect of combining these treatments has been an additive one except where the two fertilizers were applied together. In this case the fertilizer combination treatment has resulted in yields that are significantly higher than the sum of the individual treatment yield increases, in some seasons.

On the basis of these results, it is recommended that either ammonium sulphate or double superphosphate, each at 1 cwt. per acre, or cattle manure at the rate of 10 tons per acre broadcast in alternate years over the bed surface, should be applied in the early Long Rains. For optimum yields both of these recommendations should be carried out.

References

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- (2) ———, *A.R. Dept. Agric. Kenya*, 1955, Pt. II, 105.
- (3) ———, *A.R. Coffee Research Station, Ruiru, Kenya*, 1956/57 (Fig. I and Table XLVIII).
- (4) ———, *A.R. Coffee Research Station, Ruiru, Kenya*, 1956/57, 69.
- (5) ———, *A.R. Coffee Research Station, Ruiru, Kenya*, 1956/57, 70.
- (6) ———, *A.R. Coffee Research Station, Ruiru, Kenya*, 1956/57, 73.
- (7) ———, *A.R. Coffee Research Station, Ruiru, Kenya*, 1956/57, 75.
- (8) ———, *A.R. Coffee Research Station, Ruiru, Kenya*, 1956/57, 76.
- (9) ———, BROOK, T. R., and DE VINK, H. H. J., *E. Afr. agric. J.*, 1955, **21**, 69.

PLANT PHYSIOLOGY

GROWTH RECORDING TRIALS

At the Coffee Research Station (C.R.S.) there was a marked period of growth in February and March, most probably as a result of the January rainfall, diminishing to a resting time in July-August, when growth was resumed, to reach a low peak in October. In both cases the main growth preceded the time of heaviest rainfall, although some rain had fallen previously to stimulate the trees (Fig.III). The increase, as usual, was greater on multi-stem than on single-stem trees.

In the Scott Agricultural Laboratories (S.A.L.) there was a rather different picture (Fig. IV). Both types of trees showed a gentle increase in growth in February just after the unusual rainfall in late January and early February, diminishing to a minimum in July for multi-stem but a high peak in late July for single-stem with a common minor peak recorded for October-November.

The rainfall at both stations was well above normal and, as a consequence, little irrigation was applied so that there was no effect due to this factor.

All the growth curves for treatments such as shaded and unshaded, irrigated and non-irrigated followed the same pattern, the only deviation being the previously mentioned response by single-stem trees in the July-August period at S.A.L. As in previous years, the rate of growth of multi-stem trees was somewhat greater than in single-stem trees.

TABLE LXXIII
Yield corrected for cwt./acre of clean coffee

	<i>Unshaded</i>		<i>Shaded</i>		<i>Means</i>
	<i>Unwatered</i>	<i>Watered</i>	<i>Unwatered</i>	<i>Watered</i>	
Single	2.43	2.68	1.61	2.55	2.32
Multi	2.01	2.52	3.50	2.50	2.63
Means	2.22	2.60	2.56	2.53	
	2.41		2.55		

GROWTH RECORDS 1957, C.R.S.

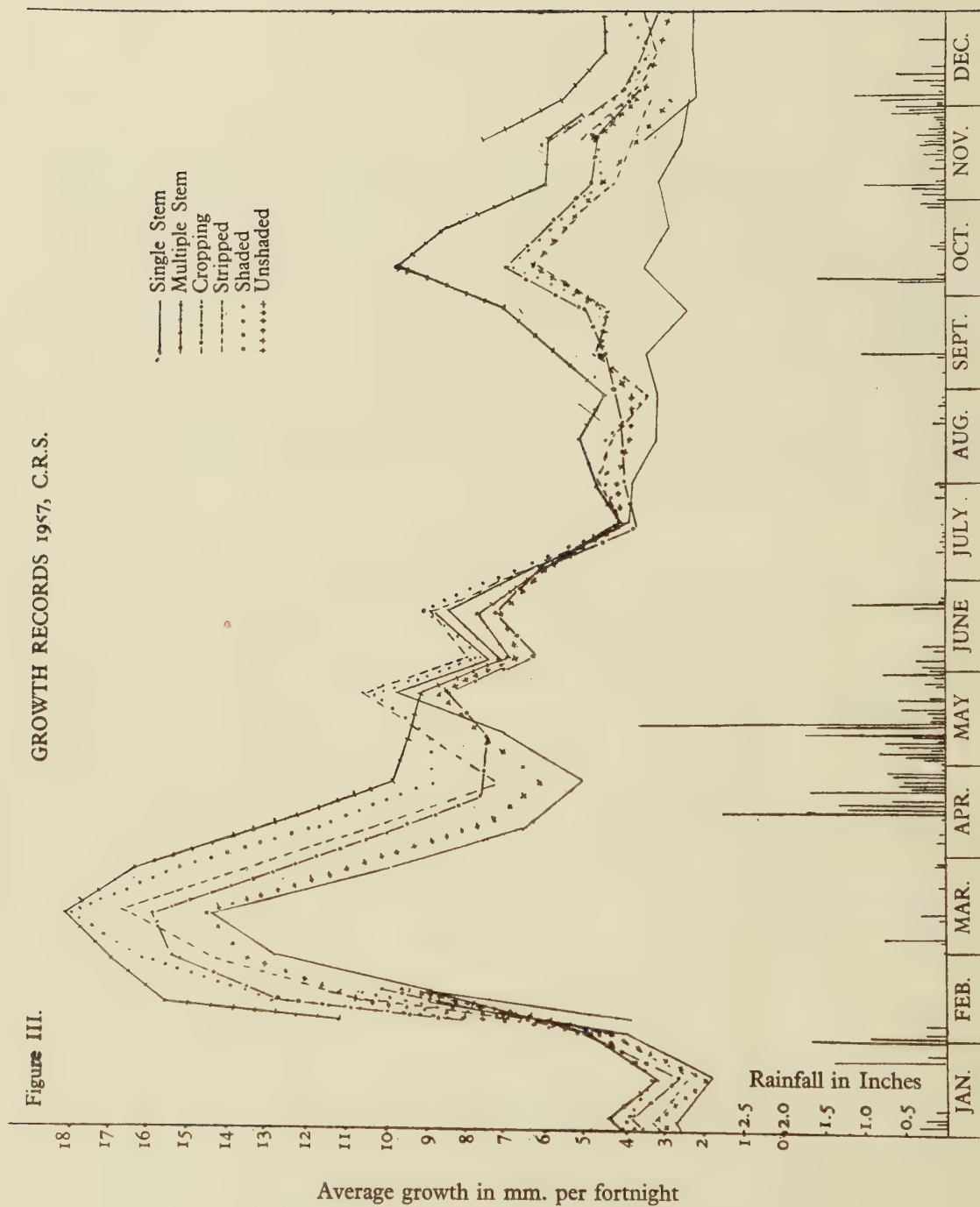
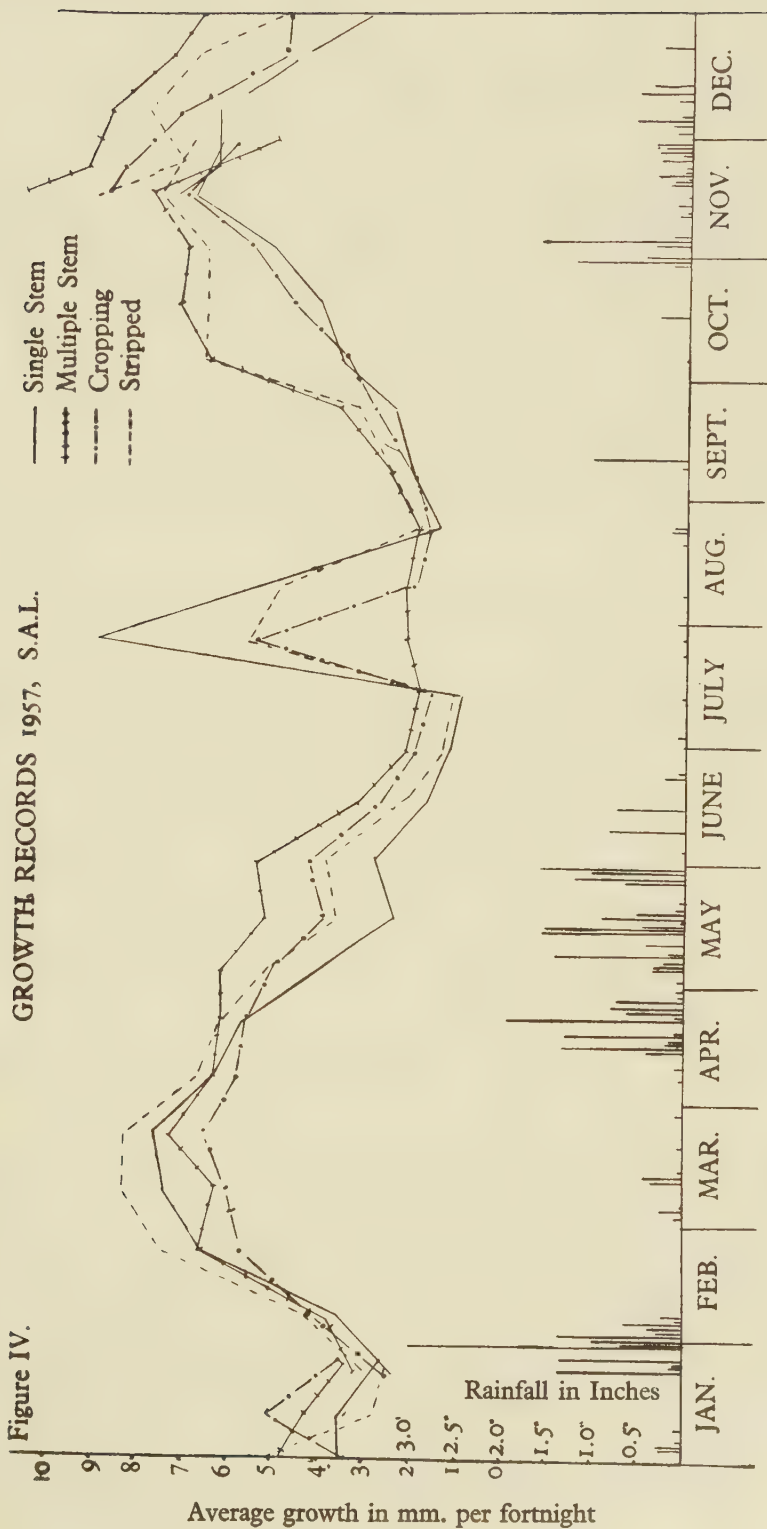


Figure IV.



PLANT PATHOLOGY

Leaf Rust

The record rainfall of 1957 caused severe rust conditions throughout the coffee-growing areas of Kenya.

Since rain fell during January and the first week of February in 1957, the infection from the Short Rains of the previous year was carried on with no setback from leaf-fall and there was a very high level of infection at the beginning of the Long Rains. There were many "Infective periods" at this time and as the incubation period of *Hemileia* at this time of the year is about one month, many generations of Rust were able to proliferate spores.

Really good spraying was essential to give control of the disease and avoid an epidemic. If the first Main Spray recommended for January was omitted, then the *Hemileia* received no check and built up to very serious proportions. The Second and Supplementary Sprays were absolutely necessary this year although the timing of the latter was different owing to the frequent rainy periods precluding a definite pinpointing of the onset of the Long Rains.

Thus, although liberal rainfall brought heavy cropping it also brought a heavy toll of Leaf Rust and subsequent defoliation.

TRIAL TO INVESTIGATE TIMES OF APPLICATION OF ANTI-RUST SPRAYS

An experiment to compare the effects of spraying on four different dates was laid down. There were three blocks, of 32 plots, each containing ten trees of which the alternate ones were sprayed—covering all the combinations of the four spraying times, which were : October 16, 1957, January 14, 1958, March 17, 1958, and April 28, 1958. Perenox at a concentration of 10 lb. per 100 gallons and 5 lb. per 100 gallons of water was applied at the rate of 2 pints/tree, with Warley hand pumps. The recording was made by counting the number of infected leaves per 100 on four sections of each tree.

The result of the first count showed that the lower concentration gave control in the region of 50% and the higher was 5% more effective. By March the effect was reduced to 10.8% for the first and 22.7% for the latter, after which the effect diminished rapidly until none was apparent in July.

The January spray followed the same path, decreasing in effect from a maximum in March. The results of the later sprays are still being recorded.

TRIAL TO INVESTIGATE THE EFFICACY OF DIFFERENT SPRAYS AND CONCENTRATIONS

This trial was designed to test three different sprays—Perenox, Blitox and Burgundy, at three different strengths— $\frac{1}{2}\%$, 1% and 2% of copper equivalent, on upper and lower surfaces of leaves. Each plot consisted of ten trees of which five were sprayed and alternate trees left unsprayed to act as controls. There were 18 plots per block with three replications.

The sprays were applied in October and a Rust count recorded in January. Later counts showed that the effects of the spraying had vanished, therefore it would be advisable to repeat the experiment and take recordings at earlier dates. From the single recording, it appeared that the three sprays were practically equivalent in efficacy with slight variations which were not significant. Perenox was more effective at the higher concentration and Burgundy at the lower. The higher concentrations were very significantly effective in all the types of spray, showing that the rate of 10 lb./100 gallons was a valuable control of Rust.

One treatment was so unsatisfactory that a field error was suspected, hence it is advisable that the experiment should be repeated to obtain a fuller check.

GERMINATION TEST OF HEMILEIA

A quantity of spores of *Hemileia* was collected and placed in specimen tubes as follows: Race I in two tubes of which one remained in light and the other in the dark, and the same with Race II. Every day at 9 a.m. hanging drops were prepared from these different collections and kept in the dark until 2 p.m. when a count of germinated spores in 100 was taken.

Over a period of 23 days there was little difference between the germination of spores kept in the light from those kept in the dark, but the total viability diminished during the period. Race I had a considerably lower germination percentage than Race II. Parallel material was placed in an oven at 30°C. for germination but proved unsuccessful. The normal temperature during the period was between 16° and 20°C. A further batch of spores are being treated in the same way.

ENTOMOLOGY

General Pest Situation

Attacks of Leafminers, *Leucoptera meyricki* Ghes. and *Leucoptera coffeina* Washb., occurred on many estates in the Central Province, mainly towards the end of the year.

Leaf Skeletoniser, *Epiplema (Leucoplerma) dohertyi* Warr., continued to do damage on estates in Ruiru and Thika. Where control measures were taken, malathion 50% emulsion concentrate applied by tractor-drawn machines at a rate of 2 pints per acre gave good control of these moths and their larvæ. Lead arsenate similarly applied at a rate of 2½ lb. per acre also gave excellent control of the larvæ.

Few outbreaks of *Antestia*, *Antestiopsis* spp., were noticed during the year.

The Coffee Lacebug, *Habrochila ghesquierei* Schout., continued its spread in Kiambu and had reached a few estates in Ruiru by the end of the year.

Tip Borer, *Eucosma nereidopa* Meyr., continued to do damage to berries and terminal growth in Upper Kiambu. Although studies on biology and parasitism were continued no practical control of this pest was evolved.

White Stem Borer, *Anthores leuconotus* Pasc., continued to do damage in coffee-growing areas prone to infestation by it. With widespread and concerted action in such areas, using the dieldrin banding method of control, there was real prospect of bringing this insect to the point of extinction.

Scale Insects. An unusually large area of coffee was found to be infested by the Brown Bark Scale, *Lecaniodiaspis erratica* de Lotto, on an estate in Kiambu. Treatment with malathion was, however, effective on this insect, particularly on the nymphs. The Fringed Scale, *Asterolecanium coffeæ* Newst., caused trouble on some estates but was controlled with oil emulsion sprays. The Coffee Mealybug, *Planococcus kenyæ* (Le Pelley), was only noticed sporadically throughout the year and no serious attacks were found.

Other Pests. An unusual item was an attack of a large slug, *Trichotoxon* sp., on several estates in the Donyo Sabuk area. The slugs did damage by removing the pulp from ripe berries on the trees, and the pulp appeared to be palatable to them whether still red or completely dried. On one estate 150 acres were infested by them. Where control measures were taken, metaldehyde baits were effective.

Insecticides

With the demonstration of the value of the insecticides malathion and diazinon against many serious coffee insect pests, particularly the sucking insects (*Hemiptera*), the Leafminers *Leucoptera* spp. and other moths, the coffee-grower is now in a much better position to apply effective measures to control most of the pests he encounters. This position is now even more favourable, in that better spraying equipment is available in a variety of forms to suit his needs. It is now possible almost to eliminate insecticides of long residual action from the spraying recommendations, so that there is less fear of interference with the complex of beneficial insects associated with coffee. Insecticides of long residual action, when applied as spray-bands against ants attending scale insects or White Borer, are still essential, but are not recommended as foliage sprays.

A comprehensive taint trial carried out with a range of insecticides demonstrated that no taints were imparted to coffee with parathion, malathion or diazinon used at normal concentrations. A lindane wettable powder formulation did, however, impart "bricky flavour", an undesirable taint associated with the use of BHC insecticides.

Research on Insect Pests of Coffee

1. *Antestia*. *Antestiopsis* spp. Experimentation with malathion against *Antestia* continued and recommendations for its use were issued. A full account of this work was published in the Bulletin of the Coffee Board of Kenya in June. Growers who followed these recommendations were invariably successful in obtaining good control of this serious pest.

2. *Leafminers*. *Leucoptera meyricki* Ghes. and *L. coffeina* Washb. Experiments with insecticides and investigations into the life histories of these insects were pursued. Resulting from these studies

it was found possible to achieve control of the moths as well as larvæ within the leaves with diazinon, and to control the moths with malathion. Suitable spray-timings were determined and recommendations for controlling these pests were published in the Bulletin of the Coffee Board of Kenya in December.

3. *Coffee Lacebug*. *Habrochila ghesquierei* Schout. No infestations suitable for experimentation were found during the year. However, before completion of this report a range of insecticides was tried against it. Of these, parathion was the best, but was very closely followed by malathion. In view of the hazards to spray operators associated with the use of the former insecticide, malathion is recommended for the control of lacebug. Two sprayings were found necessary, the second to be applied 21 days after the first in order to eliminate the population resulting from the relatively few eggs not killed by the first spray application. Malathion should be applied at a strength of 1 pint of the 50% emulsion concentrate in 40 gallons of water on each occasion.

In a trial of aerial spraying against *Antestia*, it was found that the 2 pints of malathion concentrate applied per acre by this means also had good effect on Lacebug. The mortality of eggs was not, however, so great as is achieved by using ordinary spraying machines. It was nevertheless demonstrated that this method could afford a means of rapidly containing an attack. Research continues on this pest.

4. *White Borer*. *Anthores leuconotus* Pasc. Field experiments evaluating the efficiency of dieldrin spray-bands were continued. It has now been demonstrated that three applications of $\frac{1}{2}\%$ dieldrin applied previous to consecutive rains, i.e. over a period of 18 months, completely eliminates boring larvæ. Dieldrin spray-banding is now recommended to growers whose coffee is infested by this insect. The results of a banding trial comparing $\frac{1}{2}\%$ dieldrin alone with $\frac{1}{2}\%$ dieldrin plus 0.26% dicoumarone resin are shown in Fig. V. Borer control was equally good in both cases and the extra cost of the resin is not justified.

Miscellaneous Items

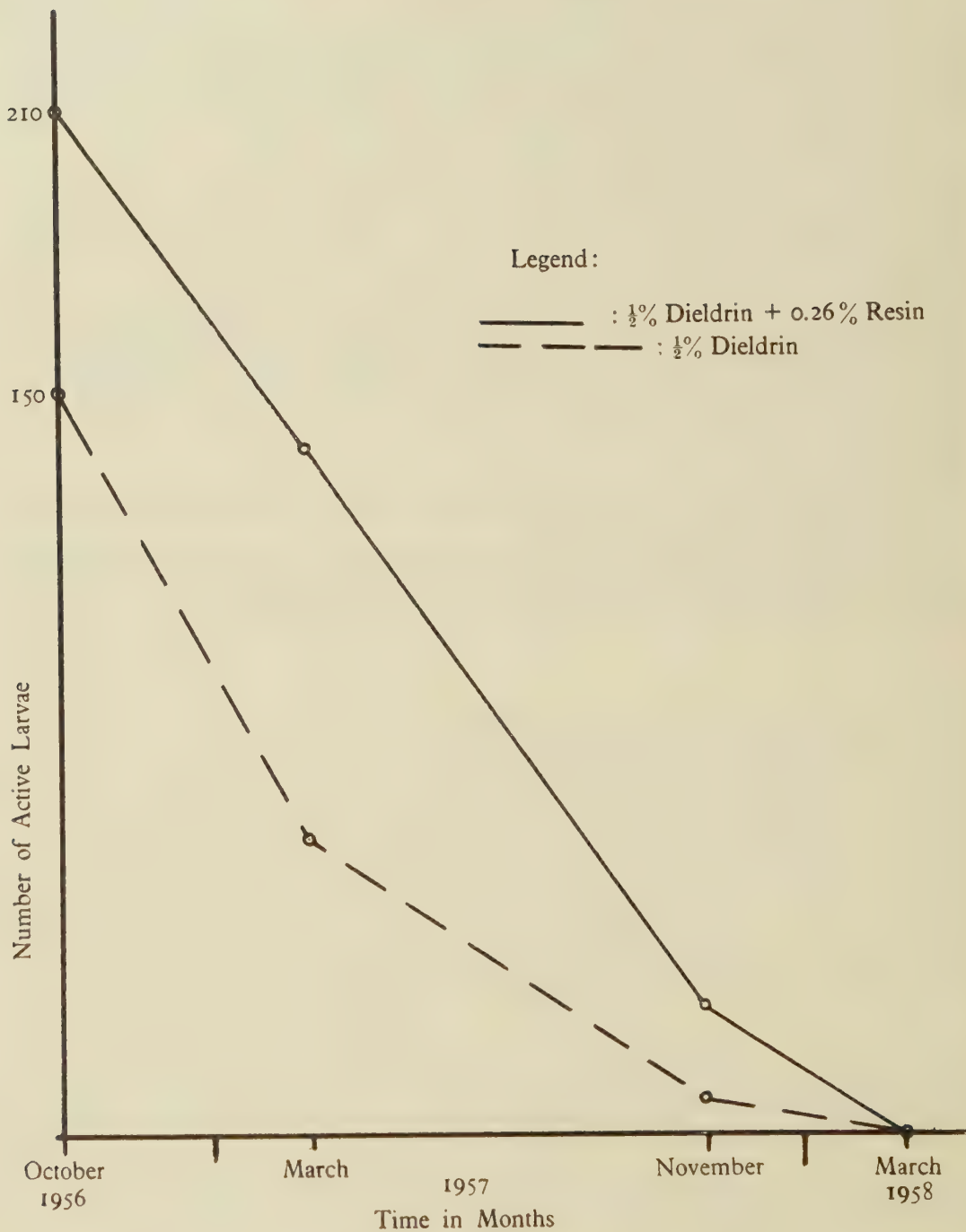
Much assistance was received from the Commonwealth Institute of Entomology in the identification of insects, and this is gratefully acknowledged.

Mr. G. de Lotto rendered much assistance in identification of Scale Insects and mealybugs.

As usual, many growers permitted experiments to be done on various pests on their estates during the year. Their assistance in this aspect is most gratefully acknowledged.

Figure V.

THE EFFECT OF DIELDRIN SPRAYBANDING ON WHITE BORER



COFFEE BERRY DISEASE RESEARCH

Contributed by Dr. F. J. Nutman, Senior Principal Scientific Officer i/c Coffee Berry Disease Research Unit

During the year the full results of the 1956 series of field experiments became available and are summarized below, together with the conclusions drawn from them.

I. January-March 1957: Results of the 1956 Field Experiments, and their interpretation

Experiments were initiated in March, 1956, on several estates in each of four localities. These included Upper Kiambu, North Lumbwa, Nandi/Kapsabet and Cherangani. In June the experiments were extended to Mount Kenya (Nyeri) area, where it was planned to investigate mid- and late-season losses attributable to coffee berry disease. The experiments, of varying design, were directed mainly towards investigating the effects of time and frequency of sprays, and as such must be regarded as being preliminary. The bulk of the spraying was done with a preparation containing phenyl mercuric acetate, though additional fungicide trials were laid down at two sites. The results of these experiments are summarized under their locality headings.

1. Upper Kiambu

The results of the three 2⁵ factorial experiments, designed to investigate the effect of timing of sprays on the disease, clearly indicated that the most critical period for control occurred over the blossom period. 20-30% increases in yield were obtained from one well-timed blossom application. No later treatments, that is, no treatment applied over the period following blossoming (May-October), gave any response.

2. Mount Kenya (Nyeri) Areas

Two applications of Phenyl Mercuric Acetate applied in July and August increased yield by 20% (an equivalent increase of 2 cwt. parchment coffee). Subsequent applications gave no response.

3. West Rift Areas

The Cherangani trials were made invalid by the fact that expected severe attack did not materialize. At Lumbwa and Nandi, in spite of extremely variable material and irregular disease distribution, certain trends were clearly evident—early blossom applications were having an effect on what was to be considered a peak infection period, and that mid-season applications (August-October) were having an effect on a second epidemic phase.

The Kapsabet trial proved extremely informative. The responses of the different varieties are summarized in the table below, the figures given as cwt./acre.

TABLE LXXIV

Variety	Untreated	Treated	Response (= % increase)
Blue Mountain	1.6	3.6	125
S.L.28	2.2	3.6	63.6
Kenya Selected	1.1	1.8	63.6
Series A	0.9	2.2	144.4
SL.30	0.5	1.8	260.0
SL.34	1.2	2.6	116.7
SL.9	1.7	3.0	76.5

From the above results, taken as a whole, it must be concluded that an economic fungicidal control of coffee berry disease is possible. Several other important facts were discernible. The importance of blossom applications was made clear. It could be inferred from a study of the responses that the epidemiology of the disease varies considerably for Kiambu, Mount Kenya and

West Rift areas. Briefly, Kiambu figures hinted at one epidemic period centred on blossoming; West Rift hinted at two epidemic periods—over blossoming and again at any time between July and September. Mount Kenya areas showed severe attack in July and August.

The 1957 series of trials, based on these results, were carried out on the same experimental areas and sites, excepting Cherangani and Nandi.

II. March-December 1957

More critical designs and techniques were used—for example, the use of guard rows between sprayed plots was abandoned and screens used. Uniformity of material was the first criterion of site selection.

The fungicide trials were extended and the number of formulations to be tested increased. The Kiambu and West Rift trials received true pre-blossom treatments, and only at Nyeri was the issue complicated by virtue of a heavy November flowering which preceded the first spraying. The application of treatments went on steadily and satisfactorily in all areas throughout the season. Unfortunately the main series of fungicide trials, sited at Upper Kiambu, was completely destroyed by hail. The West Rift and Nyeri trials, unfortunately, were comparatively small ones; consequently, information on many possible formulations is at present lacking.

In September the first signs of phytotoxic effects of mercurial sprays were observed simultaneously at Nyeri and Kiambu. These first took the form of an extremely delayed leaf scorch and die-back, but were later to assume a more serious set of symptoms which have since been attributed to an induced zinc deficiency. Investigations on the latter were started in October, and in November/December preliminary experiments on possible remedial measures were undertaken. These are in progress at the moment.

Notes on trends of the 1957 results

The main facts emerging from the results at present at hand (final figures will not be available until February 1958) are summarized briefly below.

1. The Kapsabet trial has given comparable results with those of 1956, though the responses have doubled and in some cases trebled. There is now no doubt that Blue Mountain is subject to severe blossom attack in certain climatic conditions, and that other varieties such as SL.28 and SL.34 are far superior in yielding capacity.
2. Kiambu experiments are giving a greater response and again this is completely confined to the blossom group of applications.
3. A mercurial formulation containing 8-hydroxyquinoline appears to be as effective as phenyl mercuric acetate, and the associated phytotoxic effects are mild compared with those of phenyl mercuric acetate.
4. A secondary effect of spraying has been observed. With all formulations, the fruit size and therefore the bean size is considerably increased over that of the controls. This is probably a reflection of the increase in leaf area observed and quantitatively checked in August/September, i.e. before the secondary phytotoxic effects were manifest. The early sprays again would appear to have exercised the major effect.

It is clear from the field data that the responses are quite inexplicable on any hypothesis involving simple protection from or eradication of fruit infection. This will be referred to later in this report.

Laboratory work already begun on the relations between the fungus and climatic conditions such as temperature and humidity have been completed and 1956 results confirmed and extended. Attention has been directed to the infective process in relation to time, plant variety, temperature, humidity, the part of the plant attacked, its age, the effect of wounding, and the past history of the inoculum. The results are now being prepared for publication. Two points might be referred to here. It is clear that the observed varying susceptibility of the berries of any given variety with age and the very high susceptibility of flowers is closely correlated with spore germination rates. For example, of a particular batch of spores, only 4% germinated on green berries compared with 66% on flowers. On the other hand, the different susceptibility of varieties is not to be explained on this basis but seems to be the result of some difference, chemical or physical, of the epidermis of the berries.

A study of the effect of fungicides on fungal growth, infection, germination and so on has been undertaken with a view to obtaining a reasonably accurate assessment of the value of a given preparation. Very great technical difficulties were encountered but eventually a method which seems adequate was developed. All fungicides now under test have been screened in this manner and new ones listed as they become available. One, of outstanding performance under laboratory conditions, is now being tested under field conditions.

The fact that a precisely-timed series of treatments, centred round the blossoming period, has so profound an effect was unexpected and, has been pointed out previously, is inexplicable on the basis of current views. An understanding of what is actually happening is therefore called for in order to determine with precision the correct times of application in the various districts—these being known to vary.

A hypothesis has been put forward whereby the development of an epidemic in a plantation is ascribed, in the main, to infection derived from the branches, the infection derived from the crop being of subsidiary importance, except perhaps in certain districts with extreme climatic conditions. In order to investigate this possibility, new methods for assessing the infection-potential of specific parts of the coffee tree have been successfully devised and preliminary work has given results which strongly support the hypothesis given above. Detailed study of this is planned for the next crop season.

In addition to the research work outlined above, observation of many plantations, mainly at the request of their owners, has been made and routine diagnoses carried out.

RESEARCH INTO THE MECHANICAL DRYING OF ARABICA COFFEE

Mr. J. F. McCloy, Senior Scientific Officer, East African Industrial Organization, continued to work on the problem of coffee drying, assisted during the period June, 1957, to January, 1958, by Mr. J. S. Grant, Assistant Agricultural Officer (Coffee Processing). The following report is extracted from the East African Industrial Research Organization Annual Report.

During the 1956-57 season, a large number of field-scale experiments with conventional driers had resulted in the formulation of empirical rules for the operation of such driers, based on combined sun and machine drying techniques.

A novel oscillating drier for the rapid removal of surface water had been constructed and some storage trials carried out. Introductory laboratory trials indicated that severe quality damage would result if wet coffee was dried at over 100°F. and it has been concluded from tests with ultra-violet lamps and a review of the data so far accumulated that sun radiation played little or no part in producing quality.

To begin the 1957-58 season it was therefore decided to carry out a large-scale pilot trial using the best techniques developed and two 2-ton batch bed driers were constructed and fitted with modern oil-fired heat exchangers. A 48-hour drying cycle, using alternate 12-hour periods of cold and hot drying at a maximum temperature of 100°F., was selected and the driers were used to prepare partially sun dried coffee at about 42% moisture content for storage in masonry bins at about 15%.

First tests showed no damage to quality—a result supported by 90 samples drawn from 52 tons finally treated. After a storage period of about three weeks, the coffee was withdrawn from the bins for final sun drying and dispatched for milling. Comparison against normal fully sun dried coffee showed that in the bulk samples very serious damage had occurred involving a loss in value of £2,000.

A set of four identical miniature laboratory tray driers was constructed and a series of 68 tests carried out to show the effects of pre-drying in the sun and final machine drying temperature. It was conclusively shown that damage was reduced by predrying, and increased by increasing final drying temperature, but that damage could not be eliminated in fully wet coffee even when dried at atmospheric temperature. By moving the laboratory driers out of doors, it was then shown that the cause lay in the absence of sunlight. After some difficulties from excessive infra-red heating, the photosensitivity effect was conclusively demonstrated with both filament and gas discharge lamps. Tests were finally put on to a routine basis using a bank of eight fluorescent tubes (Philips TL/40/54 Cool Daylight) at 7 inches above a single layer of beans. It has now been shown that :—

1. The effect of ultra-violet radiation is principally to cause yellowing of the bean parchment.
2. The effect of visible light is to cause desirable bleaching of silver skin and the production of blueness in the endosperm.
3. The effect of heating, either by infra-red radiation or by hot air, is to cause extreme sourness in the liquor at drying temperatures of 85°F. and above.
4. Light has some effect on liquor, raising the allowable drying temperature and improving the liquor of heat-damaged beans.
5. The photochemical process is largely independent of the dehydration process in the range 54 to 12% moisture content, it also being possible to partly restore the damaged appearance of beans dried in the dark by exposing them in the dry state at 10% to sunlight.

Preliminary tests on unreliaibly small samples of beans using I.C.I. coloured Perspex filters have suggested that the colour, and perhaps also the liquor forming frequencies, may be confined between 4000 and 5000 Å.

Filtration studies are continuing in the laboratory using Chance-Pilkington glass colour filters and on a larger scale using 2 ft. by 4 ft. sheets of coloured Perspex in sunlight.

This work has emphasized the need for further study of the behaviour of coffee in storage and microscopic and fluorescent examination has shed some light on two forms of gross deterioration—

“mottling” and “green water damage”. Natural ageing has been recognized to have a typical fluorescent appearance, allied to that of “mottling”, and a characteristic brittling of the cellular structure is involved. “Green water damage” has been recognized as a normally superficial effect causing vivid discoloration of the epidermis cell contents, but seldom penetrating into the endosperm, though it has not been established if the effect is caused solely by external contamination (probably by basic hydroxides) or whether it can arise by auto-contamination.

Apparatus has been constructed for the determination of moisture content desorption isotherms using a wet and dry bulb technique with recirculated airflow. The apparatus is extremely simple and, observing reasonable precautions to ensure equilibrium of humidity and temperature by using long sample storage times and by enclosing the apparatus in an incubator, consistent results are being obtained at a rate far greater than that possible with the classical saturated solution technique.

Oil extraction and free fatty acids measurements have been started, the highest FFA so far recorded being under 0.5 for beans stored for six months at 11% moisture content.

As the result of complete failure of standard germination techniques due to radicle ejection and mould growth, field trials have been started with promising results. Indications are that light treatment does not effect germination and that lethal drying temperatures are higher than liquor damage temperatures.

Tests have suggested that heat-damage sourness in liquor is due to endosperm and not embryo contents.

Tests on the effect of storage at the fully wet stage have indicated the extreme practical importance of avoiding delayed skin drying and attention has been focused on a possible association between the intractable “brown tinge” silver skin colour defect and incomplete fermentation and washing.

AFRICAN COFFEE-GROWING

With the increasing importance of the African Coffee Industry an Agricultural Officer (African Areas) was appointed in 1956 to act as Liaison Officer between the Coffee Research Station and the District Agricultural Departments throughout Kenya Colony. The chief function of the Agricultural Officer (African Areas) is to advise Field Officers of the Agricultural Department on the growing and processing of coffee, referring particular problems for investigation to the specialist Coffee Research Officers.

A proportion of the Officer's time is also taken up with the collection of information from the numerous variety trials established within and outside of the present commercial coffee-growing areas. Courses of instruction are held at the Coffee Research Station for European and African Agricultural Department Staff connected with African coffee development.

During 1957 two new coffee sub-stations were opened to serve the African areas at Kisii, South Nyanza District, and at Mariene, Meru District; these Stations were visited at frequent intervals.

African Coffee Development

The approximate acreage of coffee planted by Africans at the end of June, 1957, was 15,300 acres. With new plantings proceeding at a rate of over 5,000 acres per year the planned acreage envisaged in the Swynnerton Plan of 71,500 acres by 1968 should be attained before this date. The entire African coffee expansion programme is being controlled carefully by the Agricultural Department so as to ensure that Kenya will continue to be known as a producer of high-quality coffee. Quality standards are of great importance; the instruction of the African grower is centred therefore around the need to produce coffee which will realize the highest prices on the world market.

It should be recognized that the African coffee-growers have benefited greatly from the fund of information on coffee-growing that has accrued from the experiences of the European planter and from coffee research. In each development area only the most suitable variety is selected for planting for every set of climatic conditions. This information is derived from exploratory variety trials.

In the season 1957/58 the total African coffee crop was 2,047 tons or about 10% of the total Kenya crop. This compares with 1,521 tons in the 1956/57 crop season. The percentage of African coffee production classified in the first three classes during 1957/58 was 52% compared with 48% in the 1956/57 season, thus indicating that the quality of African produced coffee remains at the same high level.

Factory Development

In some Districts it has been found that owing to topography or to climatic conditions it is essential to economize in the use of water when processing coffee. A factory was designed incorporating a dry feed system and Aagaard Screen. The Aagaard Screen eliminates the need for constructing the usual pre-washing channels required in a factory using a rotatory or shaker sieve. Early results from this type of factory erected in Kiambu District have shown that there was a considerable saving in water consumption and the coffee produced was of a high quality.

Selection of New Coffee Areas

Before an area is scheduled for commercial coffee development several years are spent in collecting information from Variety Trials which are sited strategically within the prospective coffee area. The rainfall and temperature records are examined critically and special observations are made concerning the soil type and the depth of the soil profile. Valuable information is obtained from the variety trials indicating whether the area is capable of producing good-quality coffee or whether certain pests and diseases or an adverse climatic factor(s) will make this impossible. The results of yield records and liquoring samples enable a firm recommendation to be made concerning the most suitable variety of coffee to be grown in the area. If the variety trials are a failure they still

serve an important purpose in demonstrating that coffee cannot be grown successfully in a particular area. As soon as an area has been found suitable for coffee-growing, the precise limits are defined in the *Official Kenya Gazette* permitting coffee-growing to commence under the close supervision of the Department of Agriculture.

The Kisii and Meru Coffee Sub-stations

The purpose of these two coffee sub-stations is to carry out experimental work on coffee problems under local environmental conditions. During the period before the end of March, 1958, all work at both stations was concentrated upon clearing the areas to be planted with coffee in the years 1958/59.

